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State Geological Survey

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Year-Book for 1908.

H. FOSTER BAIN,

DIRECTOR.

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STATE GEOLOGICAL COMMISSION.

GOVERNOR C. S. DENEEN, *Chairman.*

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H. FOSTER BAIN, *Director.*

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LETTER OF TRANSMITTAL.

UNIVERSITY OF ILLINOIS, March 31, 1909.
STATE GEOLOGICAL SURVEY,

Governor C. S. Deneen, Chairman and Members of the Geological Commission:

GENTLEMEN—I submit herewith material forming the year book of the Survey for 1908, with the recommendation that it be printed as Bulletin No. 14. It includes a review of many activities in geology, topographic mapping, and educational work. Of especial interest are the papers on Studies of Illinois Coals, many of which were contributed by investigators outside of the survey corps. The report of the proceedings of the Illinois Fuel Conference is also included, although it was actually held early in 1909. To this meeting is to be credited the interest which resulted in the organization of a department of Mining Engineering at the University, and also the strong support for the Mine Rescue Station established at Urbana, in coöperation with the U. S. Geological Survey. The year has been one of great effort and considerable accomplishment.

Very respectfully,
H. FOSTER BAIN, *Director.*

ADMINISTRATIVE REPORT FOR 1908.

(By H. Foster Bain, Director.)

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ADMINISTRATIVE REPORT.

Introduction.

General.—Illinois ranks third in mineral production. Complete figures for 1908 are not available but probably the total will not differ greatly from that for 1907 when the value of the mineral output amounted to $152,221,284.00. Omitting pig iron, produced in Illinois but made mainly from imported materials, and a part of the zinc production for the same reason, the output was $93,415,404.00. This total, large as it is, is small in comparison with our possibilities. For example since 1902 the Portland cement output of the State has remained nearly stationary despite the increasing use of such cement and the presence of abundant material within the State. In the meantime many new plants have been built in neighboring and competing states. In many lines of clay goods we import rather than manufacture. Silica and certain other materials, occur abundantly in the State but are so little known or so little appreciated as to have been very slightly used.

To assist in the economical development of these and all our other mineral resources, the State Geological Survey was created. Its functions are broad and it has a part in the solution of all public problems into which a knowledge of geology enters. The finding of limestone suitable for use on acid soils, the regulation of our rivers and the reclamation of undrained lands, the location of materials for use on the public highways, the bettering of conditions in our coal mines, the finding of adequate public water supplies, the better direction of exploration for gas, oil, and other buried resources of our commonwealth; with all these problems the State Survey, either alone or in coöperation with other State bureaus, is concerned. Its work is educational—the collection and dissemination of as accurate knowledge as possible regarding our mineral resources and our geological environment—of the great natural platform on which our civilization and our industries depend. Its methods involve field studies, laboratory tests, library research, and comparison with other areas and with industrial development in other states. The investigation is necessarily continuous since conditions change and new knowledge renders necessary and valuable a re-interpretation of old observations. The present State Geological Survey was organized in 1905, no appropriation having previously been made since 1875. There was in a sense thirty years of back work to do, since during all that time drill holes had been put down and changes had taken place which needed to be made a matter of record and study if they

were to be used. A new organization was to be created and methods adapted to this particular field needed to be developed. Much of this has now been done. The various steps so far taken are detailed in this and the preceding administrative reports.

The work is now organized and the methods determined. The rate of progress will be measured largely by the funds available and with much of the work the sooner it is done, the sooner the people of the State will get the benefit. The work is of cumulative value. One topographic map has an important but still local value; a complete set of maps of a river valley permits the economical and wise planning of the regulation of the river for power, navigation, land reclamation and water conservation. A single map in an oil field is of some value; but complete maps of the field, or better still, structural maps of the whole area, permit very accurate determination of the areas favorable for prospecting. A single sample and analysis of coal means little; but a complete set of analyses and samples for a field or a State may mean the entry of the coal into a wholly new market. It is important therefore to keep steadily at the work and to do it on as generous a scale as the revenues of the State will warrant. That the work now being done answers a real need is shown by the hundreds of requests for specific information which come to the Survey office and the thousands of requests for reports. Indeed the demand for reports is so great that it has been necessary to increase the number printed and also to print in one case a second edition. It will probably be necessary to print repeated editions of several of the bulletins.

Organization and Personnel.—The organization of the Geological Survey in 1908 remained substantially the same as in 1907. Three sections were recognized: (a) geologic; (b) topographic; (c) drainage. The first was administered by the director, aided by Assistant State Geologist DeWolf. The second was in charge of W. H. Herron, Geolrapher in Charge of the Central Section for the U. S. Geological Survey. The third was directed by Mr. Herron assisted by E. W. McCrary, engineer.

Within the year comparatively few changes occurred in the personnel. On July 1st R. S. Blatchley joined the corps and was assigned to the duty of making a detailed study of the Robinson oil field. At the close of the field season he assumed in addition the duties of chief clerk. Miss Opal Lockwood began work as clerk on July 1st and G. M. Wood left the survey to take up private work in November. In addition to the regular corps as given below Messrs. F. E. Layman, C. F. Knirck, A. J. Ellis, W. E. Deuchler and a number of others served for short periods of time in the field or office. The general organization, exclusive of certain temporary employés was as given below:

COMMISSIONERS.

Governor C. S. Deneen, Chairman.
Professor T. C. Chamberlin, Vice Chairman.
President E. J. James, Secretary.

ADMINISTRATIVE WORK.

H. F. Bain, Director.
R. S. Blatchley, Acting Chief Clerk.
Samuel Abrams, Clerk.

GEOLOGICAL SECTION.

F. W. DeWolf, Assistant State Geologist.
R. D. Salisbury, Consulting Geologist.
U. S. Grant, Consulting Geologist.
C. W. Rolfe, Consulting Geologist.
S. W. Parr, Consulting Chemist.
Edward Bartow, Consulting Chemist.
Stuart Weller, Geologist.
T. E. Savage, Geologist.
J. A. Udden, Geologist.
A. V. Bleininger, Ceramist.
E. F. Lines, Assistant Geologist.
R. S. Blatchley, Assistant Geologist.
Jon. Udden, Field Assistant.
G. H. Cady, Field Assistant.
J. C. Jones, Field Assistant.
Opal Lockwood, Clerk.

TOPOGRAPHIC SECTION.

W. H. Herron, Geographer.
W. J. Lloyd, Topographer.
M. Hackett, Topographer.
E. W. McCrary, Assistant Topographer.
A. T. Fowler, Assistant Topographer.
C. B. Kendall, Assistant Topographer.
W. A. Gelbach, Junior Topographer.
G. L. Gross, Junior Topographer.
Lee Morrison, Junior Topographer.

DRAINAGE SECTION.

W. H. Herron, Geographer.
E. W. McCrary, Engineer, in charge of Kaskaskia River Surveys.
W. J. Lloyd, Topographer, in charge of the Big Muddy River Surveys.
P. E. Fletcher, Engineer, in charge of Primary Levels.
G. M. Wood, Clerk.

Coöperation.—As in previous years the State Geological Survey has worked in close coöperation with a number of other organizations. With the U. S. Geological Survey there has been formal coöperation in the topographic work, the study of the coal fields, and the collection of mineral statistics, and informal coöperation in the drainage work and the study of clays, of cement materials, and of water resources. The special work of the State Committee on Water-Ways Reclamation has continued with the active coöperation of the Internal Improvement Commission and the U. S. Department of Agriculture. The chemical studies of coal have been carried on as heretofore in connection with the Engineering Experiment Station, the Graduate School and the Department of Applied Chemistry of the University of Illinois. The arrangement covering exchange of information with the State Water Survey has continued. Augustana College has furnished official facilities for J. A. Udden in his work of collecting and studying drill records and the University of Chicago for the men writing educational bulle-

tins. In the State Conservation Commission, organized by the Governor in December, the State Survey is represented by the Director. It is expected that through this commission an even better coördination of the State work and closer coöperation with the various State bureaus will be brought about.

Acknowledgment should be made to the numerous firms and individuals who have supplied the Survey with drill records and other notes often of a confidential character. The response to our requests for such information has been everywhere instant and hearty and the records now being collected and correlated will be of the highest value in the difficult task of working out the stratigraphy of the deeply buried portions of our great coal and oil fields.

Geological Section.

The administration of the geological section of the Survey has been in the hands of the Director and Assistant State Geologist DeWolf. The principal work of the year has been directed toward:

(a) The collection and compilation of drill records with a view to the making of a preliminary structural map of the State.

(b) The study of the coal fields of the State as a whole with a view to the preparation of a general report in advance of the detailed mapping.

(c) The completion of the investigation of the Portland cement materials of the State, including the sampling and testing of the clays and shales.

In addition the usual work of the bureau of information, that of collecting mineral statistics, and the studies of stratigraphy and of mineral resources were carried on. The details are given in following pages.

General Stratigraphy.—The principal work of the year has been in connection with the collection and study of deep drill records. In a State such as Illinois, in which outcrops are relatively rare and over which there is quite generally a thick drift cover, the careful preservation and study of deep drill records is especially important. Only by this means will the geology of much of the State ever be learned. Deep holes are usually drilled in this area in search of water, coal, or gas and oil. The methods of drilling for these differ materially. Expert drillers for one may be quite inexpert when looking for the other. The men in one industry are seldom in touch with those in either of the others. On this account the work has been organized in three sections: F. W. DeWolf being in charge of the collection and study of coal test drillings, R. S. Blatchley looking after oil and gas well records and J. A. Udden collecting and examining drillings from wells put down in search for water. In each case the general purpose has been to collect and correlate the records of as many deep borings as possible. This is being done both by correspondence and personal visit. Each boring is located as accurately as possible and its elevation above sea level determined by reference to railway grade or to actual surveys where necessary. For convenience in reference a map has been prepared with a tack bearing a key number in each township for which records are available. At present there are nearly 5,000 records in our files. These are fairly

well scattered over the State though there are considerable areas in which we have none. In others the records are incomplete and inaccurate and it will be necessary to secure better ones. This, and the study of those at present available, is the work now being undertaken. The details are given under the separate subjects.

The study of these records can not prove of great value except in connection with corresponding studies of the outcrops of the rocks. The general work on the stratigraphy of the State is therefore being pushed forward rapidly, Stuart Weller of the University of Chicago remaining in general charge of this phase of work. He has devoted his personal attention to the Mississippian rocks, being assisted by Jon Udden. The Mississippian system is one of the most important in the State. In its upper portion are found some of our most productive oil sands. In lower beds are limestones and shales suitable for making Portland cement, stone for making lime, for building, for road metal, for use on soils, and for other purposes. In the same rocks are found the fluorspar, lead and zinc deposits of Pope and Hardin counties and certain minor occurrences of zinc not as yet found to be of commercial importance in the western part of the State. The Mississippian rocks, over much of the State form the base upon which our Coal Measures rest and from both the scientific and practical points of view they constitute one of the most important formations in the State. It is of first importance that their stratigraphy be understood and Dr. Weller is therefore devoting his main attention to them with a view to the preparation of a general report upon the subject.

The rocks below the Mississippian including the Devonian, Silurian and Ordovician, outcrop over considerable areas in Southern Illinois and are capable of yielding large amounts of stone of various kinds. In them also occur the silica deposits which are becoming more and more important. The stratigraphy of these rocks has been in some confusion and T. E. Savage has been assigned to work them up. He has spent parts of two field seasons in the area and has done his laboratory work under the direction of Professor Schuchert at Yale University. Important results have already been reached and a full report on the subject is in preparation. In the northern portion of the State the first steps have been taken toward a much needed re-study of the Niagara rocks. A. J. Ellis, acting under Messrs. Savage and Weller, has undertaken the collection of notes and specimens along the Niagara-Ordovician contact with very interesting results.

The general study of the Coal Measures has been carried out in connection with Mr. DeWolf's studies of the coal. The principal stratigraphic work has been done by David White, kindly detailed to that work by the U. S. Geological Survey. Upon the basis of correlations made by him, Mr. DeWolf and the various members of the State Survey working in the coal fields are preparing a wholly new map of the coal fields. Messrs. White and DeWolf spent some time in a general reconnaissance through the western part of the State studying the relations of the Coal Measures to the Pottsville and lower rocks. This trip was followed by one through the southern counties by Messrs. White, DeWolf and Bain, for similar work. At the close of the work in Illinois, Mr.

White spent some weeks in similar studies in Indiana, very greatly to the advantage of the work in our own State and it now seems probable that a satisfactory correlation of coal beds and a uniform nomenclature for the whole Eastern Interior Coal Field will be developed.

In the extreme southern part of the State is a limited area covered by rocks of the Cretaceous and Tertiary age. In 1906 a reconnaissance of this area was made by Mr. DeWolf, but since then it has been impossible to spare any one for further work on these rocks. Fortunately the Federal Survey is engaged in a general study of the rocks of the Mississippi embayment and will be able shortly to send some one into this area. There are important fire clays, shales, and road materials to be derived from them and better knowledge of their stratigraphy is much needed.

Above the hard rocks over most of the State is a variable thickness of sand, gravel, and boulder clay resulting from the action of great ice sheets which in Pleistocene times covered so much of the State. Despite the great scientific and practical interest of these beds the Survey has been unable to spare any one to take up their systematic study. During the season just passed, J. C. Jones, acting under the supervision of R. D. Salisbury, made a study of the Pleistocene deposits of the New Haven-Galatia area. W. C. Alden, for the U. S. Geological Survey, spent a short time in the study of the older drift sheets of northwestern Illinois. In the studies for educational bulletins, the glacial deposits of several areas have been studied, but there is room and need for a thorough general study of these deposits. In the Pleistocene are found the water supplies of most of our villages and towns; the gravels needed for road construction and for railway ballast; the sands for concrete and other building construction; clays for brick, drain tile, etc.; important local sources of natural gas; and the distribution of the deposits controls, primarily, the character of our soils. Fortunately a general study of these deposits is available having been made some years since for the U. S. Geological Survey by Frank Leverett.[1] Much new data is however now available and many gaps remain to be filled. A map showing the distribution and character of the gravel beds of the State may be mentioned as one of the pressing needs which might be met by a study of these deposits.

Coal.—Illinois ranks second among the states in the production of coal. In 1907, 51,317,146 tons, having a total value of $54,687,382.00, were mined. The figures for 1908 are not complete but preliminary estimates indicate that Illinois was almost alone among the states in holding its production. While in the country as a whole the amount mined fell off from 15 to 20 per cent, Illinois mines produced nearly as much as in 1907, a record year. Despite this gratifying fact it remains true that our mines are not working to anything like their capacity. In 1907 the average number of days worked was 218. It would probably be fair to assume 300 working days a year as possible. On this basis there was a loss of thirty per cent of the possible working time and this is not an unusual per cent of loss in our State.

[1] The Illinois Glacial Lobe, Mon. 38, U. S. Geological Survey.

The reasons for this are complex. In part they lie in the nature of the coal which prevents its storage without spontaneous combustion; in part, in the general ignorance as to correct methods of firing and the real value of the coal; and finally in part, in the present organization of the industry with excessive competition in selling. The net results are bad for the industry and therefore for the State as a whole. Cheap coal reduces manufacturing costs but allows wasteful burning. It also entails wasteful mining and even prevents the introduction of methods of safeguarding the men in the mines. It is a serious question whether we are not paying, in loss of life in the mines, in loss of efficiency in our plants, and in loss of interest and capital invested in the industry, more than the cheapness of the coal is worth.

A better understanding of what our coal resources are and the best methods of utilizing them will contribute largely to the solution of the various problems of the coal industry. To that end the work of the Survey has been organized so as to cover both field and laboratory investigations. They have continued to be under the immediate supervision of Assistant State Geologist DeWolf. The field investigations are for the purpose of acquiring exact information regarding the distribution of our coal beds, their number, thickness, character of floor and roof, the dip, any faulting which may be present and, in brief, all data necessary to an exact inventory of the workable coal of the State and the natural conditions which influence the methods of working. This work is being carried on in coöperation with the U. S. Geological Survey which bears half the expense. The method is to make exact maps locating all natural outcrops or available drill holes, to determine their elevations, and to correlate the various coal beds with a view to making structural contour maps such as already have been presented in the year books of the survey. In final publication these maps are to be accompanied by reports discussing in detail the mineral resources of the areas. This final publication is to be made by the Federal government which assumes all the expense of the necessary printing and engraving.

The work so far completed includes reports on the Peoria quadrangle by J. A. Udden, of the Springfield quadrangle by T. E. Savage, on the Belleville-Breese quadrangles by J. A. Udden and on the New Haven, Eldorado and Galatia quadrangles by F. W. DeWolf. The survey of the West Frankfort quadrangle by Messrs. DeWolf and Cady is complete and a report is being prepared. The Herrin quadrangle was surveyed in the season just closed by T. E. Savage but a report will probably not be prepared for some months. A strip six miles wide extending from south of Marion to south of Harrisburg, and covering a portion of the area of coals No. 5 and No. 6 was surveyed this season by W. E. Deuchler under direction of G. H. Cady and the report is in preparation. Level lines were run to all known drill holes, and, while this area is outside the region topographically surveyed, it is believed that it can be satisfactorily mapped on this basis. It is proposed to extend similar surveys over the entire coal fields as rapidly as funds will permit and to execute them in such detail as the data available will allow. Something over 700 drill records have been collected and the holes located and leveled to, in the course of these detailed surveys.

Aside from the surveys mentioned, and in advance of the topographic mapping, Messrs. DeWolf and Jon Udden have been engaged in a study of the coal fields as a whole and the collection and correlation of drill and shaft records. These, in connection with the work of David White on the correlation of the coal beds will afford the basis for a general report upon the coal fields as a whole. In this connection Mr. DeWolf has made a special study of the Danville district and its relations to the Indiana coal fields and Mr. Udden, a careful study of the structural features of the Duquoin area. Practically all the coal producing counties of the State have been visited.

The field work included the careful sampling of all coal beds examined. There are now available satisfactory face samples of the coal in 148 mines, representing probably all seams worked. Less satisfactory samples of 129 mines are also available. Of this earlier series forty-one have been checked by later work and are included in the first figure given. The others are being checked as rapidly as possible.

The laboratory work on coal is directed toward the determination of its composition and heating value both in the mine and as actually marketed, and the solution of various chemical problems bearing on its better marketing and utilization. This work is being done in coöperation with the Department of Applied Chemistry of the University and the Engineering Experiment Station. It is under the direction of Professor S. W. Parr who in 1908 was assisted by W. F. Wheeler, J. M. Lindgren and for part of the year by C. K. Francis and Perry Barker.

A large volume of analytical work has been carried on within the year. Preliminary reports on part of this work have been published.[1] During the year 1908 face samples from approximately one hundred different mines were analyzed by Messrs. Wheeler and Lindgren. In addition a great many duplicates were taken for checking purposes and seventy samples of the collection of 1906 were analyzed for ash and moisture. Studies of field and laboratory methods were also carried on. These included comparison of samples from different parts of the same mine, comparison of samples obtained by quartering and in the laboratory, studies of moisture absorption by samples ground respectively by ball mill, discs and bucking board. A study was also made of accuracy of moisture determinations when based on coals of various sizes. These results will be published in a report by the Engineering Experiment Station.

Weathering tests commenced a year ago have been finished and the results are nearly ready for publication. The samples include coal of two sizes from each of three mines and smaller samples stored under water. Weathering tests in coöperation with W. L. Abbott of the Commonwealth-Edison Company, Chicago, are also under way. Studies in spontaneous combustion have been started by Mr. Wheeler for the Experiment Station. The preliminary results indicate that coal stored in heaps takes fire much below usual combustion temperatures. This increases the difficulties in the way of coal storage but does not necessarily preclude success.

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[1] Trans. Amer. Inst. Mining Engineers, Chattanooga Meeting 1908.

In the report of 1907 the following regarding the desirability of certain investigations in mining technology was printed: "It has been found impracticable at the present time, mainly owing to limitations of funds, to undertake certain hilghly desirable studies of the technology of the mining industry and of the geographical distribution of markets for Illinois coals. It is believed that much good would result from investigations along these lines and that certain portions of the work are well within the proper field of the State Geological Survey. It is now well known that there is, under present commercial conditions, an enormous waste in the mining of Illinois coal. In individual districts it has been estimated to amount to as much as sixty per cent, though of course such losses are not general. It would, however, probably be safe to say that in very many places forty per cent of the coal in the ground is left unmined or is ruined in the process of mining. In addition, the methods of mining introduced in recent years have greatly increased the production of fine sizes and have also, seemingly, increased the danger to life and property in the mines. The causes for all these losses are complex, and it is not to be supposed that either operators or miners willingly submit to them. Neither is it to be expected that the losses of life and property can be entirely done away with. At the same time experience has abundantly proven that careful and impartial investigations of such conditions will point the way to the remedy for at least some of the abuses, and in view of the enormous importance of the subject to the State and the public at large, such studies are believed to be amply warranted. Fortunately it now seems likely that the United States government will take up a general study of the most complex of the problems—causes and preventions of explosions and other accidents in mines. This still leaves, however, many important local problems to be investigated; problems that are in no way national, and it is hoped that the State Survey may be given the means of taking them up.

"The expansion of markets for Illinois coal is a matter of vital importance to the coal industry and indirectly to the people of the entire State. One of the most important means of promoting this expansion is by removing certain misapprehensions as to the quality of the coal and the pointing out of better means of burning, so as to increase its efficiency and decrease the smoke produced. This work has been taken up vigorously by the Engineering Experiment Station, which has published excellent bulletins on 'How to burn Illinois Coal Without Smoke,' and other similar subjects. In addition to this valuable work, there should be investigations of the actual markets for the different grades of coal and of possible enlargements of these markets. There are large areas to the northwest within which Illinois washed coals might profitably supplant eastern coals now being sold. There are other areas to the south and west where, with proper organization of transportation agencies, even in advance of improvement of the rivers, trade territory could be gained. Any widening of the market would be of large benefit to the local industry, particularly if the summer market could be increased. For this reason the studies now under way relating to weathering of coal and coal storage are especially important."

Since the above was written the study of mine accidents has been taken up by the Federal government and a branch station has been established at Urbana for the demonstration of apparatus and methods of rescue. It is believed that this will do much to decrease the number of accidents and of fatalities. The general problems, however, of regular underground work and of better markets for our coal remain untouched. The last is peculiarly a local problem and it is believed much good would be accomplished by collecting and disseminating correct information regarding it. No elaborate investigations are called for but one or more men should be employed for so long a time as may be necessary.

Clay.—The clay-working industries of the State are in satisfactory condition. In 1907 the total output was valued at $13,220,489.00. In 1908 the output was as large, but owing to lower prices the total value may prove to have been less. The principal business is as yet the manufacture of low priced products; building and paving brick and structural materials. These industries have grown with the population until Illinois now ranks fourth in total output of clay wares. It is to be expected that with increased wealth and leisure, the per capita consumption of these and higher priced lines of manufactured goods will increase. With our wealth of raw material and fuel it is possible to manufacture to advantage much that is now imported and at some future time it cannot be doubted that this will be done. In the meantime as evidence of the satisfactory economic basis of our brick industry it may be mentioned that one of the larger plants now ships standard building brick into territory extending from New York to St. Paul and that despite the business depression many of our plants ran full time and some even refused orders in 1908.

Within the year the report upon Illinois Paving Brick and Paving Brick Clays, prepared in coöperation with the Department of Ceramics by Messrs. Rolfe, Purdy, Talbot and Baker was published. This report is based upon careful studies not only of our paving brick and clays but also of those with which they come in competition and which are marketed in Illinois. The results of elaborate studies show that Illinois clays and paving brick compare favorably with those of neighboring states. In addition Mr. Purdy's tests show a relation between the specific gravity of the test pieces burned at different degrees of heat, and the qualities of the resulting brick, so that a way is now open for testing at comparatively slight expense and with considerable security as to results, the various clays believed to be suitable for manufacture into pavers. The other important results of the work may be summarized as below:

(1) The origin of clays and their relation to the parent rock and the processes by which the rock is changed to clay, are discussed in detail.

(2) It is shown that by suitable treatment it is possible to make satisfactory pavers from a large number of clays that were previously held to be unavailable.

(3) It is shown that suitable clays occur widely distributed throughout the State and that probably no considerable area is wholly destitute of satisfactory clays.

(4) Many analyses and physical tests have been made on type clays with interesting advances in scientific and technical knowledge.

(5) An accurate series of comparative tests of a large number of paving bricks are described and valuable suggestions are given for the improvement and refining of the methods of testing.

(6) The methods of constructing and caring for brick pavements are presented in simple statement suitable for general use and methods of cheapening the cost of such pavements are pointed out. This is of particular importance in view of the large number of cities and towns which will always use brick paving.

The report as a whole is a very valuable addition to the rapidly growing series of bulletins.

The new work for the year involved the collection and study of clays of the State available for use in making Portland cement as detailed elsewhere. Since the sampling and analysis of these clays has involved considerable expense, and since they are representative of considerable bodies of clay well situated for development, it is proposed to continue their study by making general burning tests and other experiments designed to determine their range of usefulness. E. F. Lines has been assigned to this work.

The general study of the clays of the State involves the difficult problem of adequate sampling of the undeveloped deposits. Grab samples are worse than useless and samples of weathered outcrops give results which are deceptive. We are frequently called on to furnish data regarding the occurrence of clays suitable for special purposes, such as convertor linings, retort-making, and other refractory wares. The data at hand do not often permit of an adequate answer to these inquiries and the specimens sent in by land owners are not often serviceable because of defective sampling. Illinois contains much good clay. The preliminary general studies of the stratigraphy of the deposits and of methods of testing have been carried out. These should be followed by more detailed field studies accompanied by careful sampling and laboratory tests which are beyond the means now at the disposal of the Survey. It is hoped that some suitable provision may soon be made for this work.

Cement Materials.—In 1907, the State produced Portland and natural cement to the value of $2,725,326.00. The investigation of the cement materials of the State begun in that year was continued with the special object in view of determining the location and quality of deposits of clay and shale to be mixed with the limestones already analyzed. This work was under the immediate direction of A. V. Bleininger who was assisted by F. E. Layman. Mr. Layman visited all the localities where the work of the previous summer showed the occurrence of limestone suitable for making Portland cement, and collected samples of the clay most available for mixing with the limestone. This involved careful work since it was necessary to get an adequate quantity of unweathered material from a deposit suitably situated for development and large enough to furnish a supply for some years. About 100 pounds of clay, representing a much larger quantity of material collected in the field, were shipped to the laboratory for each locality. This was quartered down and subjected to analysis and test. The result of the work as a whole will, it is believed, furnish an accurate guide to our very im-

portant deposits of Portland cement making material, though no attempt has been made to sample every promising outcrop. The report is being prepared for the press by Messrs. Bleininger, Layman and Lines.

Portland cement is one of the most widely useful of modern building materials. The growth of the industry from 42,000 barrels in 1880 to 48,785,390 barrels in 1907 is one of the great industrial developments of America. In the opinion of many competent judges the future development will be even greater than that of the past. The exhaustion of our forests, with the natural desire of an older and richer people to build better, the wide increase in the variety of uses for cement, the desirability of conserving our iron and steel, and the fact that our permanent improvements both public and private are still largely to be built, all point to an increasing demand for cement. Illinois with its favorable situation regarding raw materials, fuel and transportation ought to look forward to supplying not only its own needs but those of much of the territory to the north and west. It is a pleasure to be able to state that our investigations show an abundance of material of suitable quality in situations favorable for development and to predict that a successful and expanding industry will follow. The excellent plants now in operation will necessarily not only be increased in size but supplemented by others to meet the future demands of the market.

Quarry Products.—Within the last season no attempt has been made to carry forward the special studies of quarry products. In 1906 and 1907 a number of quarries were visited and in coöperation with the State Highway Commission the availability of the rock for highway construction was determined. Many more quarries and natural outcrops remain to be sampled, but with the force now available it is impossible systematically to carry forward this work. The importance of these studies is large since in many parts of the State it is extremely difficult to get local materials for road making. Aside from this is the fact that large sums of money are annually sent out of the State for the purchase of building stone. If our own materials were thoroughly understood and completely utilized much of this money would be kept at home. The Survey has already brought to light considerable bodies of oolite and other building stones which are apparently well situated and of suitable grade for quarrying. A special investigation of them with adequate sampling and complete tests is much needed. At present the largest local use of stone is for concrete. It cannot be doubted that the demand for this purpose will rapidly increase and with this in view it is highly important to determine as promptly as possible the locations and character of all our stone resources.

Water Resources.—Water is our most important mineral, the one most vital to our health and prosperity, the one without which life itself would become extinct. The importance of property regulating the supply was well shown in 1908 in the southern counties of the State, where, following a period of unusual flood, came a period of unusual drought. Then streams ceased to flow. The ordinary wells and other sources of supply were taxed to the limit, and in many cases failed altogether. Coal washers and factories were shut down, street and interurban cars ceased

to run, and in places the supply was barely sufficient for the actual necessities of health and sanitation. The whole industrial machinery of the region was disarranged. If such conditions follow a drought in this area now, it may be well asked what will happen as the population increases in density. It is estimated that in the next century from three to four times as many people must be accommodated in our present territory and with that population a drought such as occurred this year would entail great suffering, despite the fact that Illinois lies within the area of abundant rain fall. It is not that the total supply of water is inadequate but its distribution is not satisfactory. With increasing density of population also, the difficulty of procuring uncontaminated drinking water is rapidly increasing and often the problem of securing adequate and suitable water for industrial purposes in favorable locations is a severe one.

With many of these problems the Geological Survey has no direct concern, the responsibility resting rather on the State Water Survey, the Internal Improvement Commission or the Board of Health. As relates, however, to the problem of distribution of water in the rocks below surface, the Geological Survey has direct concern. To the study of this phase of the general problem of water supplies J. A. Udden has been assigned. His work involves the study of underground water horizons by means of outcrop studies and the usual collection and study of deep well drillings. In the past season he has especially studied the area lying between the Illinois and Mississippi rivers. Already several hundred drill records are available. It is, however, especially desirable that this work should be based upon first hand knowledge of the drillings themselves. To that end arrangements will be made with any individual or municipality contemplating deep drilling in the State, for examination of the work. Directions for taking the samples and bags for sending them to the laboratory will be furnished. All needed laboratory tests will be made without charge and all possible information will be furnished to the well owner.

In certain portions of the State it is even now possible to furnish quite accurate forecasts as to depth, quality and quantity of water available. Each new well, where the samples have been carefully taken and studied, extends the area within which such forecasts are possible and increases their accuracy. The Survey will therefore welcome correspondence with persons contemplating drilling.

In much of the State the deeper waters are not suitable for industrial purposes and their corrective treatment is a problem for the State Water Survey. Elsewhere the waters while suitable are not present within practicable drilling depths or are inadequate in quantity to the uses of a large community. For the smaller cities, however, or for single industries deep wells are often capable of furnishing a satisfactory supply. The complete investigation of these problems is necessarily a matter of some years. A beginning has been made in a special study of the water resources of the East St. Louis district,[1] and in the preparation, in coöperation with the State Water Survey, of a report upon Mineral

[1] Bull. No. 5, Postage 6 cents.

Content of Illinois Waters.[1] Mr. Udden's investigations will furnish much needed additional data which will be published in special reports from time to time, similar to his paper on the artesian wells of the Peoria district.[2] This work is being carried on in coöperation with the U. S. Geological Survey which makes a small allotment toward the expense in order to permit its extension where desirable into adjacent states.

Oil and Gas.—In 1904 there was no recorded production of oil in Illinois. In 1905 the Eastern Illinois oil fields were discovered and 156,502 barrels were shipped by tank cars. In 1906 pipe lines were extended into the area, 4,397,050 barrels of oil were shipped and the State ranked ninth. In 1907 there was a large increase of production, the State ranking third with a total output of 24,540,938 barrels. In 1908 there was another increase, the total shipments for the year reaching approximately 40,000,000 barrels. The principal production is from Clark, Crawford and Lawrence counties in the southeastern part of the State, the oil occurring in the Pennsylvania, Pottsville and Chester rocks of the Carboniferous. Immediately after the organization of the Survey the study of these fields was taken up and several papers describing the territory have been published;[3] complete reports are yet to be written.

Of prime importance in any final report on an oil field is an accurate knowledge of the relative elevation of the various oil sands. With this in view a special party was organized in 1906 to run level lines through the northern part of the field, and the elevations were indicated by suitable bench marks. The next year regular topographic work was taken up and surveys were made of the field between the Indianapolis Southern and B. & O. S. W. railway lines. In the season of 1908 the levels were extended south to connect with those previously run in the Mount Carmel area.

Supplementary to this topographic work R. S. Blatchley, assisted by Douglas Wright and J. C. Jones, collected drill records throughout the Hardinville quadrangle and accurately determined the elevation of approximately 2,800 wells. Since the close of the season these drill records have been plotted and are now being studied, in order to construct maps showing the depths to the various sands, and the recorded thicknesses of the latter. It is believed these maps will be of large service in the further development of this important field and also that they will yield valuable data for the study of the laws governing the genesis and accumulation of oil and gas. In the present unsatisfactory condition of our knowledge of these laws and of the structure of the State it is impossible to make accurate forecast. It is believed that with the more complete data now being collected this will become possible, at least in some cases.

Throughout the oil fields a certain amount of gas is found with the petroleum. The gas is now being used in the surrounding towns and in pumping oil. The individual wells have good pressure and volume but

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[1] Bull. No. 10.
[2] Bull. No. 8, Year Book for 1907, pp. 313-334.
[3] Petroleum in Illinois, by A. W. Lewis, Mining World, Apr. 14, 1906.
Petroleum Industry of Southeastern Illinois, by W. S. Blatchley, Bull. 2, State Geol. Survey, 1906
Petroleum Fields of Illinois in 1907, by H. F. Bain, Bull. No. 8, State Geol. Survey, pp. 273-312.

in the main they have so far proven short lived so that the gas is relatively of much less importance than the oil. However, the value of the product for 1907 reached $143,577.00. Outside the main field, gas has been found at a number of points and utilized at several small towns. In Pike county it occurs in the Niagara over a considerable area but with small pressure. In other places it is found in the Pleistocene or drift deposits and its presence is not necessarily indicative of large supplies or of the presence of oil at deeper horizons. C. F. Knirk has furnished a special report on gas pockets of this character.

Both oil and gas in the rock have been found at a number of places in the southwestern part of the State; notably at Sparta, Centralia and in the East St. Louis district. A large amount of prospecting is now being carried on throughout the State and the Survey is called on almost daily for information regarding the probable depth to the various oil sands and regarding the presence or absence of anticlinals. It is usually possible to give a fair estimate of the depth to the sands, but our data regarding geologic structure is not so complete. Structural features which are very slight, measured in feet, are here of very large importance as regards the accumulation of oil and gas. For this reason it is necessary to have a complete restudy of all the available drill records with exact data regarding their elevation. Many of the records now on file were made years ago and are of unequal accuracy. In few cases were the samples or drill core examined by competent geologists and accordingly there are many errors. New records are being collected as rapidly as possible and the elevation of both old and new test holes determined by reference to railway or other lines of levels. It is proposed to make a preliminary structural map of the State in advance of the detailed surveys. Such a map will be particularly useful in future prospecting for oil and gas. Good progress is being made but probably another season must be devoted to the work before any general results are available for publication. In the meantime Jon Udden has made a special study of the Duquoin area within which there is a certain amount of faulting and a small structural area of some possible significance in the finding of gas and oil.

Educational Bulletins.—The law governing the State Geological Survey, by the provision it makes for the consideration of "Scientific and economic questions * * * deemed of value to the people," and the provision that materials collected shall be distributed to "the educational institutions of the State in such manner as the Commissioners may determine to be of the greatest educational interests of the State," indicates plainly that it was the purpose of the General Assembly to provide for the educational as well as economic phases of the Survey work. In harmony with this idea, plans were early made for a series of bulletins available for use in the schools, which should put in simple form, the fundamental facts regarding the physical geography of our areas. Professor Salisbury of the University of Chicago was placed in charge of the work and seven typical areas were selected for special study. Reports upon all of these have been prepared and are available whenever the printer can handle them. The first of the reports, that on the

physical geography of the Evanston-Waukegan region by Messrs. Atwood and Golthwait was published as Bulletin 7. This has proven to be one of the most popular publications of the Survey, being favorably received by educators everywhere. It is being quite generally used in the schools of the area treated and there is a large demand for it elsewhere. Unfortunately this demand was not anticipated and the edition printed proved much too small. It will be necessary to print a second. In the meantime six similar reports are ready, and field work of this sort has been temporarily discontinued until the printing can be brought up to date.

Miscellaneous Mineral Resources.—Within the State there are a large number of minor minerals of which there is or may be a considerable output. Galena and blende, the common sulphides of lead and zinc are mined in both the northern and southern parts of the State and are known, though not as yet in commercial quantities, in the western and southwestern counties. A small amount of silver is found with the lead in the southern counties. In 1907 (according to the U. S. Geological Survey) the total values for the State were: Silver, $1,882.00; lead, $87,980.00; zinc, $86,966.00. In 1908 preliminary estimates by the Mining World indicate that 2,017 tons of blende and 93 tons of galena were shipped from JoDaviess county as compared with 2,530 and 620, respectively for 1907. In the southern part of the State the production of zinc ore is irregular and some galena is produced as an incident to fluorspar mining in Pope and Hardin counties. The fluorspar mines are among the most important in the world and yielded, in 1907, 25,128 tons selling for $141,971.00. The introduction of the open-hearth method of steel making in the place of the Bessemer process is increasing the demand for spar and promises an increasing output.

Pyrites, the sulphide of iron, occurs widely disseminated but is rarely in commercial quantities. A small amount is saved as a by-product of zinc and lead mining and at one of the coal mines of the State, at least, the "sulphur balls" are hand picked and sold for making sulphuric acid.

Silica, in the form of a weathered chert, is found in the Devonian beds of Union and Alexander counties. It is used for a variety of purposes and is probably capable of being used for many others. The stratigraphy of the deposits is being studied by T. E. Savage, while T. R. Ernest of the Engineering Experiment Station is experimenting with the material.[1]

Ochre and paint pigments of various sorts are found at a few places in the State but are very little used. Sampling and testing the materials would probably lead to the development of some of the deposits.

Glass sand of high grade is taken out at Ottawa and shipped widely. It is probable that sand suitable for lower grades of manufacture occur at other points in the State. These deposits, as also sand for building, moulding and other uses should be studied.

Whetstones are found in the southern part of the State and it is known that the formations from which these stones are taken in Indiana, extend into our State. Preliminary samples indicate that portions at least of the material are of commercial grade.

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[1] State Geol. Survey, Bulletin No. 8, 147-149; Bulletin No. 4, pp. 185-186.

Mineral Statistics.—One of the most important aids to the economic development of an area is the publication of accurate statistics of production. The survey is therefore coöperating with the U. S. Geological Survey in the annual collection and publication of the statistics of output of our mineral industry. For the year 1907 the plan adopted was that of the previous years, the State Survey undertaking to look up the delinquent producers and the Federal Survey carrying on the main correspondence. Mr. F. B. Van Horn acted as special agent and prepared Circular No. 4, containing a resumé of the production for 1907. It was preceded by Circular 3, giving the special statistics of the petroleum industry. Since these reports were gotten out at the earliest possible moment they were not complete with regard to minor products, and slight corrections are included in the figures in this report.

In collecting the figures for 1908 the plan has been changed and the inquiry blanks are in the main sent out by, and returns made to, the State Survey; the returns after tabulation being forwarded to Washington. There are now on the mailing lists 2,040 producers and the output includes coal, coke, clay, pottery, brick and tile, stoneware, sand-lime brick, flourspar, sandstone, sand and gravel, mineral paints, mineral waters, limestones, gas and oil. Because of the delay in printing this report it is possible to include the figures for 1908. For the last three years the complete totals for Illinois, according to the U. S. Geological Survey, were as follows:

TABLE SHOWING MINERAL OUTPUT OF ILLINOIS FOR THE CALENDAR YEARS 1906, 1907 and 1908.

(COLLECTED IN CO-OPERATION WITH THE U. S. GEOLOGICAL SURVEY.)

PRODUCT.	1906.		1907.		1908.	
	Quantity	Value.	Quantity.	Value.	Quantity.	Value.
Cement, natural—barrels	365,843	$ 118,221	284,599	$ 92,750	188,859	$ 68,772
Portland—barrels	1,858,403	2,461,494	2,036,093	2,632,576	3,211,168	2,707,044
Clay products	....	12,765,453	....	13,220,489	....	11,559,114
Coal—short tons	41,480,104	44,763,062	51,317,146	54,687,382	47,659,690	49,978,247
Fluorspar—short tons	28,268	160,623	25,128	141,971	31,727	172,838
Glass sand—short tons	238,178	156,684	235,716	152,619	194,722	139,172
Iron, pig—long tons	2,156,866	47,128,000	2,457,768	52,229,000	1,691,944	30,135,000
Lead—short tons	572	65,208	498	52,788	363	30,492
Lime—short tons	121,546	534,118	124,784	559,305	92,549	393,951
Mineral waters—gallons sold	574,453	77,287	720,400	91,760	685,763	58,904
Natural gas	....	87,211	....	143,577	....	446,077
Petroleum—barrels	4,397,050	3,274,818	24,281,973	16,432,947	33,685,106	22,648,881
Sand and gravel—short tons	2,419,381	886,357	4,315,275	1,215,034	6,463,026	1,363,850
Silver—fine ounces (troy)	....	....	2,900	1,900	2,000	1,100
Stone	....	2,961,456	....	3,789,342	....	3,134,770
Zinc—short tons	282	34,404	1,446	170,628	298	28,012
Other products	....	[1]1,787,807	....	[1]154,396	....	[1]34,464
Total	....	$121,188,306	....	$145,768,464	....	$122,900,688

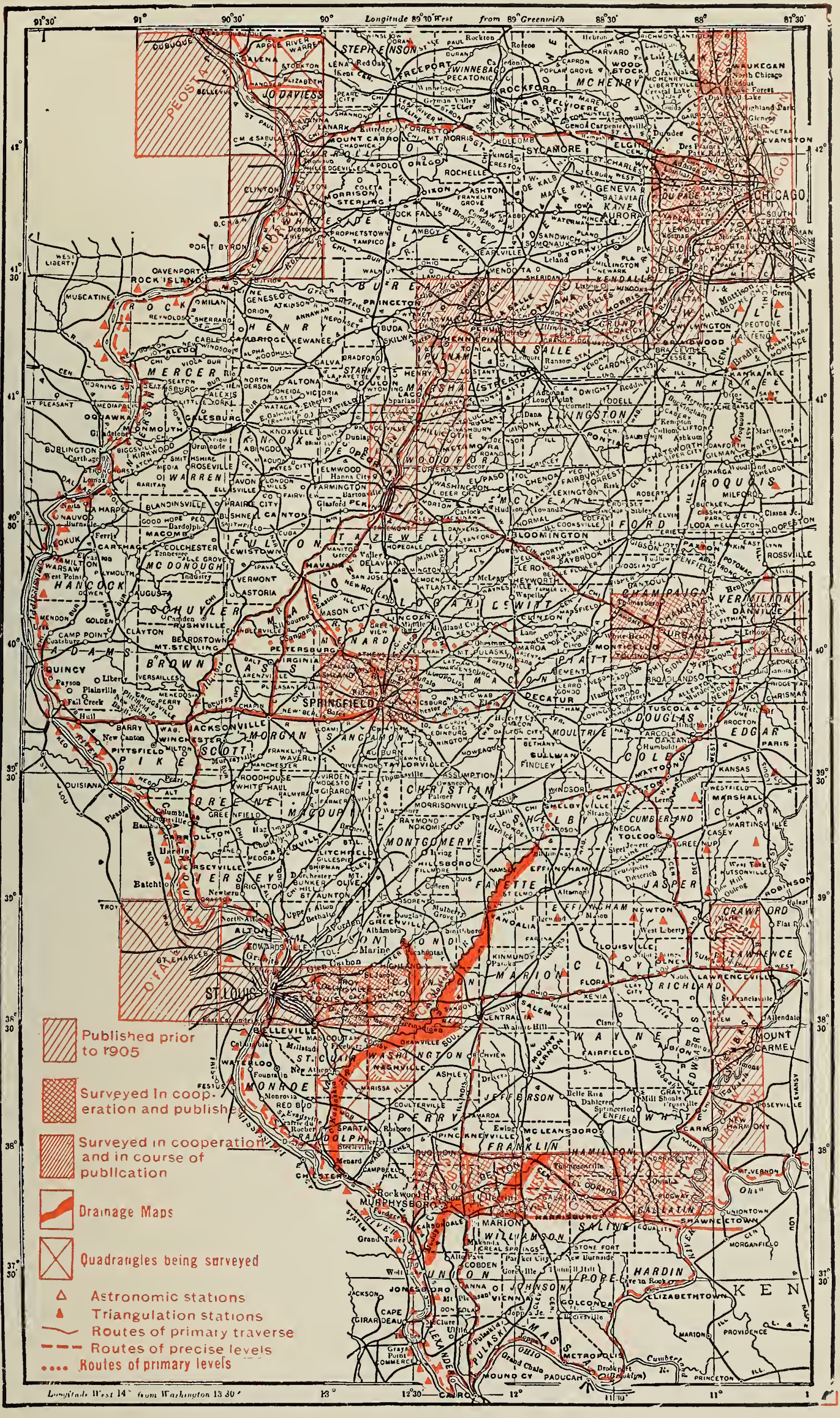
[1] Includes in 1906: Alum amd aluminum sulphate, slag cement, infusorial earth, sand-lime brick, Venetian red, and white lead; in 1907: Puzzolan cement, infusorial earth, metallic paint, pyrite, quartz, sienna, umber, sand-lime brick; in 1908: Infusorial earth, pyrite, sand-lime brick.

Bureau of Information.—One of the most important functions of the Survey is to furnish information regarding the mineral resources of the State to land owners, miners, investors and educators. A large amount of time is devoted to this work, and a great deal of correspondence is involved. The requests for information come from all parts of the country and from every part of the State. The recent requests from within the State are tabulated below. Approximately an equal number of inquiries have come from other states and countries.

REQUESTS FOR INFORMATION.

County.	Number. of Inquiries.	County.	Number. of Inquiries.	County.	Number. of Inquiries.
Adams	11	Hancock	10	Morgan	7
Alexander	7	Hardin	4	Ogle	2
Bond	2	Henderson	2	Peoria	8
Bureau	1	Jackson	6	Perry	2
Carroll	1	Jasper	9	Pike	5
Cass	3	Jefferson	3	Pope	7
Champaign	5	Johnson	1	Pulaski	3
Christian	1	Jersey	1	Randolph	4
Clark	9	Jo Daviess	3	Richland	2
Clay	1	Kane	4	Rock Island	1
Clinton	6	Kankakee	4	Saline	4
Coles	7	Kendall	2	Sangamon	27
Cook	90	Knox	6	Schuyler	4
Crawford	11	Lake	2	Scott	1
Cumberland	1	LaSalle	2	Shelby	1
DeKalb	1	Lawrence	9	St. Clair	10
DeWitt	1	Logan	1	Stark	1
Douglas	2	McDonough	8	Stephenson	2
DuPage	2	McHenry	1	Union	11
Edgar	3	McLean	4	Vermilion	9
Edwards	2	Macon	9	Wabash	3
Effinghan	9	Macoupin	6	Washington	1
Ford	2	Madison	18	Wayne	4
Franklin	4	Marion	9	White	2
Fulton	4	Mason	1	Whiteside	1
Gallatin	6	Massac	1	Will	1
Greene	5	Mercer	1	Williamson	6
Grundy	1	Monroe	3	Winnebago	2
Hamilton	1	Montgomery	12	Woodford	1

Subject.	No. of Inquiries.	Subject.	No of Inquiries.
Altitudes	4	Limestone	8
Areal surveys	7	Manganese	1
Asphalt	1	Maps	49
Bauxite	2	Mica	1
Cement	4	Mineral	68
Chalk	1	Miscellaneous	15
Chert	2	Oil	66
Clay	30	Paint materials	1
Coal	65	Pearls	1
Copper	4	Peat	6
Drainage	4	Phosphate	2
Fluorspar	9	Sand	4
Galena	2	Sandstone	1
Gas	22	Shale	1
Geology, general	4	Silica	3
Gold	1	Soil	1
Granite	2	Stone	7
Graphite	2	Swamps	2
Gravel	4	Trenton rock	1
Gypsum	1	Water	8
Iron	3	Wells	8
Koalin	1	Zinc	6
Lead	7	Zoological	3
Lime	2		



Map Showing progress of Topographic and Drainage Surveys.

These lists illustrate sufficiently perhaps the wide variety of subjects and the general nature of these requests for information. In making this table no account has been taken of the numerous requests for printed reports. The list includes only the cases requiring the preparation of a manuscript report or letter. It is not possible in all cases to give the information asked for. Often, indeed, the information does not exist. In other cases it would require expensive field studies to solve the particular problems involved. In such cases it is only possible to file the request for investigation the first time one of the field men shall be in the vicinity in the course of regular work.

In many cases the request for information is accompanied by a specimen for analysis or test. Usually the specimen has not been well chosen, and an analysis would not signify much with regard to the deposit as a whole. It is not generally understood that sampling is quite as important, and calls for nearly as much skill, as making analyses or laboratory tests. This is entirely aside from the honesty of the one taking the sample and his desire to get an average specimen of the material. Analytical work and laboratory tests are expensive, and it is desirable not to spend money on them except on the basis of good sampling. For these reasons, together with the fact that any other course would permit the whole appropriation to be used up by any citizen for private purposes, or for work of doubtful value, the Survey has been forced, in most instances, to decline to make any analyses or laboratory tests on miscellaneous material sent in by correspondents. While this occasionally leads to individual disappointment, it seems to be the only plan consistent with the present size of the appropriations, the general purpose of the Survey—a systematic study of the mineral resources of the State. In many cases it is not necessary to make an analysis in order to determine the value of the material, but the results of a physical examination are cheerfully and promptly furnished the inquirer.

Topographic Section.

(By W. H. Herron.)[1]

The plans for the coöperative topographic surveys in Illinois for the season of 1908, contemplated the completion of the topographic sketching of unfinished quadrangles begun in the previous year, the revision of the Hennepin and LaSalle maps, made previous to the inauguration of the coöperative survey, and the extension of the control, both primary and secondary, over areas to be completed in the near future. The general progress of the work is shown on the accompanying map.

It will be noted that the localities selected for this year's work are widely divergent, the Galena and Apple River quadrangles being in the extreme northwestern corner of the State, the LaSalle and Hennepin in the north central portion, the Hardinville, Bridgeport, Carmi and Shawneetown in the southeastern part, while the remainder of the quadrangles are situated in southern and southwestern Illinois. The distribution of the work has been conditioned by the needs of the mining

[1] Geographer in Charge, Central Division, U. S. Geological Survey.

industries of the State, there being an especially large demand for the maps in the coal, oil, and lead and zinc fields. The season has been an unusually favorable one, and the output has been most satisfactory.

It has been possible to utilize much of the primary control of the quadrangles in southwestern Illinois in the drainage surveys of the Kaskaskia and Big Muddy rivers, thus avoiding duplication of work, and accomplishing a saving of funds for the drainage surveys.

A summary of results of the coöperative topographic surveys in Illinois during the season of 1908 is shown in the following table:

Locality.	Square miles of topography.	Traverse, Miles.		B. M.	Levels, Miles.	
		Primary.	Secondary.		Primary.	Secondary.
Apple River			696	10	71	
Baldwin		55	594	11	78	
Bridgeport		55		19	91	321
Carlyle	156					102
Carmi		74	345	19	84	
Galena			408	11	48	
Hardinville	139		37			
Hennepin		62	556	18	67	
Herrin	105		50			
LaSalle		62	686	20	73	
Murphysboro	236		97			576
New Athens						462
Okawville	165		25	10	30	388
Shawneetown		36		3		
Vandalia	101		539			
	902	344	4,033	121	542	1,849

It will be noted from a perusal of the above table, and comparing it with that published for 1907,[1] that the Carlyle, Hardinville, Herrin, Murphysboro and Okawville quadrangles will be ready for publication as soon as the office drawings are completed, the field work having been entirely finished for these areas. The New Athens sheet needs only the topographic sketching in order to complete the field work for this quadrangle. The secondary leveling and topographic sketching are necessary to finish the Apple River, Galena, Hennepin and LaSalle quadrangles, while the secondary traversing and sketching will complete the Bridgeport sheet.

The following is the personnel of the organization arranged by quadrangles:

Apple River—Henry Bucher, levelman; F. B. Barrett, field assistant; Terry Hackett, rodman; M. F. Gannett, field assistant.

Baldwin—W. A. Gelbach, levelman; F. W. Crisp, field assistant; L. S. Bowles, rodman.

Bridgeport—W. A. Gelbach, junior topographer; W. S. S. Johnson, levelman; A. J. Hendley, levelman; Percy Kimmell, levelman; J. M. Aiken, rodman; L. S. Bowles, rodman; Mack McCreery, rodman; Thos. Gassoway, rodman.

Carlyle—A. T. Fowler, assistant topographer; E. W. McCrary, assistant topographer; A. J. Hendley, levelman; A. C. Wood, levelman; Thos. Gassoway, rodman; F. W. Hempstone, rodman.

[1] Year Book for 1907, Bull. No. 8, page 23.

Carmi—J. R. Ellis, assistant topographer; W. A. Gelbach, junior topographer; F. W. Crisp, field assistant; W. H. Snyder, recorder; L. S. Bowles, rodman; G. C. Graeter, rodman; N. Underwood, chainman; M. Underwood, rodman; F. P. Tippitt, laborer.

Galena—Henry Bucher, levelman; F. B. Barrett, traversman; F. W. Crisp, traversman; Terry Hackett, rodman; M. F. Gannett, field assistant.

Hardinville—M. Hackett, topographer.

Hennepin—C. B. Kendall, assistant topographer; G. R. Hoffman, traversman; Henry Bucher, levelman; Terry Hackett, rodman; R. C. Gaylord, rodman; J. W. Matthewson, rodman; S. L. Fuller, rodman; M. F. Gannett, recorder.

Herrin—W. J. Loyd, topographer; G. L. Gross, junior topographer; J. A. Duck, field assistant; J. W. Lowell, Jr., field assistant; J. M. Aiken, rodman.

LaSalle—W. J. Lloyd, topographer; C. B. Kendall, assistant topographer; Henry Bucher, traversman; G. R. Hoffman, traversman; Terry Hackett, rodman; R. C. Gaylord, rodman; J. W. Matthewson, rodman; S. L. Fuller, rodman; M. F. Gannett, recorder.

Murphysboro—W. J. Loyd, topographer; G. L. Gross, junior topographer; J. W. Lowell, field assistant; A. C. Wood, levelman; W. S. S. Johnson, levelman; Percy Kimmel, levelman; F. W. Hempstone, rodman; C. P. Gross, rodman; Mack McCreery, rodman; J. W. Aiken, rodman.

New Athens—A. C. Wood, levelman; H. A. Church, levelman; A. J. Hendley, levelman; Thos. Gassoway, rodman; Melvin Evenson, rodman; F. W. Hempstone, rodman; C. P. Gross, rodman.

Okawville—W. J. Lloyd, topographer; E. W. McCrary, assistant topographer; W. A. Gelbach, levelman; A. J. Hendley, levelman; A. C. Wood, levelman; H. A. Church, levelman; L. S. Bowles, rodman; F. W. Hempstone, rodman; Thos. Gassoway, rodman; Melvin Evenson, rodman.

Shawneetown—J. R. Ellis, assistant topographer; W. H. Snyder, recorder; N. Underwood, chairman; M. Underwood, rodman; F. B. Tippitt, laborer.

Vandalia—E. W. McCrary, assistant topographer; Lee Morrison, junior topographer; E. L. Hain, junior topographer; A. K. Atkinson, field assistant.

The following table shows the season's expenditures:

Balance Jan. 1, 1908		$ 3,294 18
Appropriation, United States, net	$7,920 00	
Appropriation, State, net	6,920 00	
		14,840 00
Total funds available		$18,134 18
Disbursed Jan. 1 to Dec. 31, 1908—		
Office	$ 1,820 79	
Field	14,775 78	
		$16,596 57
Balance Jan. 1, 1909—		
United States	$ 305 25	
State	1,232 36	
		$1,537 61

The office expenditures indicated were from the unexpended balance of last year, and the work consisted of the completion in the office of maps of the previous season.

Drainage Section.

Organization and Work.—The special drainage section of the Survey was organized in 1907 to take charge of the work provided for by the appropriation for the survey and study of the lands subject to overflow along our inland rivers. The need of this work has been recognized for

some years. According to estimates made for the State Geological Survey by W. Carvel Hall, there is an enormous area of land subject to overflow along our intra-state streams.

BOTTOM LANDS SUBJECT TO OVERFLOW IN ILLINOIS.

(ESTIMATE BY W. CARVEL HALL.)

River.	Estimated valley length—miles.	Estimated area of bottom land—square miles.
Embarrass	65	175
Little Wabash	85	335
North Fork Little Wabash	20	45
Skillett Fork	40	190
Olney Fork	17	15
Saline River	25	30
Big Muddy	50	45
Kaskaskia	65	245
Silver Slough	22	30
Shoal Creek	25	40
Crooked Creek	7	5
Sangamon	80	100
Salt Creek	15	20
Desplaines	285	900
Rock	80	275
Spoon	60	30
Mackinaw	30	25
Pecatonica	45	45

In this table are included only those streams which were unsurveyed. If to the areas estimated are added the bottom lands of the Illinois and its branches, surveyed by the U. S. Army Engineers in 1905,[1] and the Cache river bottoms surveyed by a State commission in 1904,[2] the totals would be much greater. Preliminary surveys have already shown that Mr. Hall's estimates are well within the truth since on the Kaskaskia alone nearly 300 square miles of bottom land are now known. The table however, will serve its main purpose in illustrating the extent and something of the distribuiton of the bottom lands of these streams.

The great interstate rivers which border Illinois, the Mississippi, Ohio and Wabash, have also extensive bottom lands. Mr. Hall estimates that in Illinois their areas amount respectively, to 1,205, 25 and 270 square miles.

Probably ninety per cent of the bottom lands of the State are unprotected or inadequately protected against floods and it is estimated that if they could all be brought under successful cultivation there would be added to the farm value of the State over one hundred million dollars. There would be additional benefits to be derived from improved health conditions, some power development and the increased navigation of the streams.

In order properly and economically to plan works which shall protect and drain the river bottom it is necessary to take into account the river as a whole. Power development must not be allowed to interfere with navigation and one drainage project must not be allowed to block the way

[1]House of Rep., Doc. 263, 59th congress, first session.
[2]Report of Board of Cache River Drainage Commission of Illinois, 30 pages, Danville, 1905.

for a more comprehensive one. No permanently satisfactory solution of the problems afforded by even one of these streams is likely to be reached except by the united action of the people of a whole valley. Large districts must be arranged and in order that they may work most efficiently, it will probably prove necessary for the State to assume at least supervisory control of the work. The State is, in fact, under certain obligations to do this. The lands, originally in possession of the general government, were given to the State upon condition that they be drained. This obligation was passed on to the counties, drainage laws being provided to permit of the work being executed. Since now a stage in the work has been reached where a considerable change in method is necessary, the State must assume its share of the burden.

A beginning has been made. In 1903 the General Assembly provided for a special survey of the Cache river bottoms. In 1905 the General Assembly passed a joint resolution looking to the improvement particularly of certain of the rivers in the southern part of the State. No definite results having been accomplished under this resolution, the General Assembly in 1907 made a special appropriation to the State Geological Survey for the survey and study of lands subject to overflow along the streams of the State. At the same time an additional appropriation was made to the Internal Improvement Commission for the further study of the rivers of the State with a view especially to their improvement from the point of view of navigation and the development of power. The State has therefore undertaken, as its share, the expense of the surveys, the studies and the supervision of the work, and, in appropriating for the Shawneetown levee, has even set the precedent of at least some appropriation for construction work.

To consider the various problems involved in river improvement in Illinois, there has been organized a State Committee on Waterways Reclamation, including representatives of the State Geological Survey, the Internal Improvement Commission, and the U. S. Department of Agriculture. The work of this joint committee is expected to result in a report upon which the General Assembly can formulate a definite policy toward stream improvement. The making of detailed maps of the different river valleys has been assigned to the Geological Survey, and is now being carried on. A report by Mr. E. W. McCrary, detailing the progress for the year, is given on the following pages. The methods used are essentially those developed by the U. S. Geological Survey, which is actively coöperating in the work.

Work is now being carried on along the Kaskaskia, Big Muddy and Embarrass and additional work along the Little Wabash and the Sangamon is planned. The special study of drainage problems will be undertaken by the U. S. Department of Agriculture, under the direction of Mr. C. G. Elliott, Chief Engineer of Drainage Investigations. Work has already been taken up along the Little Wabash river and Skillet fork.

The Internal Improvement Commission is making the general engineering studies involved, including the gauging of the streams, in which part of the work the assistance of the water resources branch of the U. S. Geological Survey has been enlisted. A report upon these phases of the work will be made by the Internal Improvement Commission.

Surveys for 1908. (*By E. W. McCrary.*)—The topographic survey of overflowed lands, begun in 1907, was continued through the season of 1908, resulting in complete surveys of the Kaskaskia river from the wagon bridge, one and one-half miles southeast of Cowden, to its outlet near Chester; Shoal Creek, from the wagon bridge six miles west and one mile south of Greenville, to its outlet into the Kaskaskia river; and the Big Muddy river from near Mulkeytown to the Mississippi. The distance along the surveyed portion of the Kaskaskia river, by direct line through the bottoms, is 118 miles; Shoal Creek, twenty-nine miles, and the Big Muddy, fifty miles. The areas surveyed are shown on the accompanying map, (Pl. 1).

In addition to these completed maps, a primary level line has been run from Beardstown along the Sangamon river to Petersburg, and from Springfield to Decatur; from Decatur the line continues north along the Illinois Central railroad to Clinton, and thence west along Salt river to the Sangamon and south to Petersburg. This line of levels will serve as vertical control for the work along the Sangamon and Salt rivers.

The total area surveyed is 496 square miles, of which 348 are included in the Kaskaskia River Survey, 48 in the Shoal Creek Survey, and 100 in the Big Muddy. Of the 348 square miles along the Kaskaskia river, 160 was surveyed in 1907, which leaves for 1908, a total of 336 square miles. There is an average of five linear miles of stadia traverse, with fifty determined elevations per square mile, which makes a total of 2,480 miles of traverse and 24,800 elevations, which are distributed along these streams as follows:

	Miles traverse.	Elevations.
Kaskaskia River	1,740	17,400
Shoal Creek	240	2,400
Big Muddy River	500	5,000
	2,480	24,800

In addition to the ground elevations, levels have also been taken of a sufficient number of high water marks to make it possible to show upon the completed maps, the extent of the flooded section. With this information plotted on the maps, it will be possible to see at a glance the extent of the flood along the entire length of the stream. Elevations have also been determined of the approximate low water, but because of the quick changes in the level of the water surface, and the lack of stream gauges, these elevations may vary as much as three feet from a given stage. However, they should be useful in giving a fairly accurate idea of the fall between different points along the stream.

In their completed form, the maps are divided into sections or sheets, which are given the name of the largest town, or, if there be no town, of the best known feature which it contains. The size of the sheets are not uniform, but necessarily vary in order to fit the changing course of the stream. The approximate size will be, to the scale of the map, 9 by 11 miles.

The scale is 1:24000, or one inch to 2,000 feet, and the contour interval, five feet. The methods used in the survey of these streams are

fully given in the year-book for 1907.[1] During 1908 the work was carried along in practically the same manner as in the preceding year. Following is a list of the completed sheets:

Kaskaskia River—Lorton Bridge, Vandalia, Sopher Lake, Carlyle, Santa Fé, Queens Lake, Fayetteville, Round Pond, Evansville.

Shoal Creek—Breese, Frogtown.

Big Muddy River—There will be five or six sheets along this stream. They were surveyed under the direction of Mr. W. J. Lloyd of the U. S. G. S., and are being put into map form by him.

Of these sheets, the Carlyle, Santa Fé and Queen's lake are now available. The Breese and Frogtown were completed February 1. The Vandalia, Soper Lake and Lorton Bridge are expected to be ready by March 1, and the remainder by April 1.

From the view point of area mapped, and the quality of the work, the year 1908 has been a successful one. However, the party in the field suffered a great deal from sickness during the summer months, there being only two out of a party of ten to escape sickness. Of the eight who were sick, five were affected at the same time, which very seriously interfered with the progress of the work. The work, as previously planned for 1908, included the Kaskaskia river, Big Muddy, Shoal creek, and a small section of the Little Wabash, south of Carmi, and the level work on the Sangamon. All of this, with the exception of the Little Wabash, was completed as planned.

The personnel of the surveying party is as follows:

Kaskaskia River—E. W. McCrary, assistant engineer; Lee Morrison, assistant topographer; E. L. Hain, assistant topographer; S. K. Atkinson, field assistant; A. L. Hambrecht, field assistant; H. P. Hancock, field assistant; R. E. Johnson, field assistant; John Fletcher, levelman; F. W. Hughes, traversman; P. E. Fletcher, traversman; W. H. Herron, Jr., rodman; Herbert Johnson, rodman; Douglas Wright, rodman; William Ahring, rodman; Ralph Atkinson, rodman; G. R. Hoffman, rodman; W. S. S. Johnson, rodman; J. W. Johnson, rodman; J. M. Aiken, rodman.

Shoal Creek—E. W. McCrary, assistant engineer; Lee Morrison, assistant topographer; J. A. Duck, field assistant; S. K. Atkinson, field assistant; F. W. Hughes, levelman; J. Lederer, rodman; Douglas Wright, rodman; William Ahring, rodman.

Big Muddy River—W. J. Lloyd, topographer; George Gross, assistant topographer; A. L. Hambrecht, field assistant; J. A. Duck, field assistant; R. E. Johnson, field assistant; W. H. Herron, Jr., rodman; Mack McCreery, rodman; W. S. S. Johnson, rodman; J. M. Aiken, rodman.

Plans.—It is greatly regretted that these surveys are not yet sufficiently advanced to permit definite recommendations for the improvement of these rivers to be submitted at this time. This phase of the subject is treated in the report of the Internal Improvement Commission.

Publications.

Reports Printed.—At the beginning of the year Bulletin 7, a report on the Physical Geography of the Evanston-Waukegan Region, by Messrs. Atwood and Golthwait, was still in press. It was distributed in the

[1] Topographic Mapping in Bottom Lands, by E. W. McCrary. Bull. No. 8, State Geol. Survey, pp. 64–67.

spring, followed in the fall by Bulletin 8, the Year-Book for 1907. Bulletin 9, a special report on paving brick and paving brick clays, by Messrs. Rolfe, Purdy, Talbott and Baker, is now in press. Bulletin 10, a report on the Mineral Content of Illinois Waters, prepared in coöperation with the State Water Survey, has been submitted for publication.[1]

The reports now available for distribution are listed at the close of this bulletin.

The distribution of these reports so as to prevent waste, and yet make them most widely available, has been in itself a considerable task. It was thought that the interests of all concerned would be best met if 500 copies of each report be reserved for sale at the cost of printing, the receipts from the sales being turned into the State treasury. This makes it possible for libraries to complete their sets and for persons having real need for any of the volumes to obtain the earlier ones at small cost. The remainder of the edition is distributed by the Survey and the Secretary of State to institutions and individuals making application for them or exchanged with other Surveys or publishing organizations.

Any of the published reports will be sent upon receipt of the amount noted. Money orders, drafts and checks should be made payable to F. W. DeWolf.

The topographic maps completed and published are distributed from Washington, the State having made no provision for publishing a local edition. They may be purchased at the rate of five cents each or $3.00 a hundred. Drafts or money orders should be sent to the Director, U. S. Geological Survey, Washington, D. C. He is not allowed to receive postage stamps or personal checks in payment. The areas already surveyed and the names of the maps are shown on the accompanying map. (Pl. 1).

Reports in Preparation.—There are a number of reports now ready for the printer or in an advanced stage of preparation. These include three educational bulletins which have been already submitted, and three others which are available at any time. The three which have been for some months ready for the printer are:

The Mississippi Valley between Savanna and Davenport, by J. Ernest Carman.

Physical Features of the Des Plaines Valley, by James Walter Goldthwait.

Physical Geography of the East St. Louis District, by N. M. Fenneman.

The three reports which can be submitted with slight delay are:

Physical Geography of the Springfield Quadrangle, by J. C. Jones.

The Middle Portion of the Illinois Valley, by Harlan H. Barrows.

Physiography of the Wheaton Quadrangle, by A. C. Trowbridge.

In less advanced state of preparation is the year-book for 1908, including a preliminary report on cement making material of Illinois; some studies of Illinois coals and other papers. Special reports on coal, oil and other materials are in preparation.

The State Geological Survey has not attempted as yet the publication of areal reports either by counties or districts. Instead, arrangements

[1] Published July, 1909.

have been made for the U. S. Geological Survey to assume the expense of publishing the areal reports. One such report, that of J. A. Udden on the Peoria quadrangle has been completed and is in process of publication. The report of N. M. Fenneman on the St. Louis-East St. Louis quadrangle has also been submitted. The Springfield quadrangle has been surveyed and a report has been prepared by T. E. Savage. A similar report upon the Belleville-Breese quadrangles by J. A. Udden is about ready for publication. Mr. DeWolf and his assistants have surveyed a number of quadrangles in the southern coal fields and preliminary articles on certain of them will be found in Bulletin 8 of this Survey. It is expected later that a combined report on the whole district will be prepared.

Expenditures.

The annual appropriation for the survey, including the topographic work, is $25,000.00. Originally $10,000.00 per year of this amount was allotted for coöperative topographic surveys. In 1907, owing to a reduction in appropriations, the U. S. Geological Survey was only able to meet an allotment of $8,000.00, and in 1908 certain new charges for administration were made against this allotment, still further reducing the Federal appropriation to $6,920.00. This has been met by an equal allotment of funds by the State. In 1908, in addition, $1,000.00 of the unexpended funds of the U. S. Geological Survey for the preceding fiscal year were available and $10,484.92 of the special appropriation made by the State for the survey and study of overflowed lands. The total funds available on January 1, 1909 are as follows:

For geologic surveys	$4,577 82
For topographic surveys	1,232 36
For drainage surveys	863 46

The detailed expenditures are listed below:

General Appropriations—		
Balance on hand Jan. 1, 1908	$ 5,306 73	
Appropriation of July 1, 1908	25,000 00	
Total available		$30,306 73
Expenditures Jan. 1, 1908, to Jan. 1, 1909—		
Salary and expenses of director	$4,027 33	
Clerical help and general office expenses	2,323 91	
Surveys and laboratory studies of coal fields	4,779 38	
Surveys of clay deposits	635 24	
Studies of cement materials	877 73	
Surveys of oil fields	969 78	
General stratigraphic studies	1,831 24	
Educational series	835 13	
Water resources	682 31	
Mineral statistics	135 00	
Special studies	144 20	
Printing expenses	1,184 01	
Miscellaneous	383 65	
Topographic surveys	5,687 64	
Total		24,496 55
Balance available Jan. 1, 1909		$5,810 18
Special appropriation for survey and study of overflowed lands—		
Balance on hand Jan. 1, 1908		$10,484 92
Expended in 1908	$9,621 46	9,621 46
Balance available Jan. 1, 1909		$863 46

Recommendations.

In view of the needs of the Survey and the numerous demands upon it, the following recommendations are made:

1. That the present annual appropriation for the general support of the Survey be increased from $25,000 to $35,000 annually. This is necessary if the reasonable demands for increased work along the lines now being pursued is to be met. In support of this recommendation, it may be pointed out that since the State Geological Survey was established, the mineral industry of the State has enormously increased. Excluding pig iron and spelter, the total output in 1904 amounted to $56,400,829.00. For the same items in 1907 the total was $93,415,404.00 and for 1909 probably an even larger amount. It is not claimed that this increase, amounting to 65 per cent, is due to the activities of the Survey, though the latter doubtless had some influence. It may be pointed out, however that this increase in production has very greatly increased the work of, and demands on, the Survey. At the time this bureau was established and the size of its annual appropriation fixed, there was no oil production in Illinois. We have now a production of nearly 40,000,000 barrels. This has brought millions of dollars into the State, and has also brought hundreds of requests to the office of the Survey for information regarding depth to various horizons, location of anticlines, etc. It has not been possible to give satisfactory service to this industry because we have not had the men nor the money to hire them. At the completion of Mr. Blatchley's season in the oil field this year it was necessary to practically stop the work and leave the results undigested and unstudied, and therefore largely valueless, because of the pressure of routine work in the office. If the information asked for by the oil men could be promptly and accurately supplied now that they are in the mood for prospecting, very large developments would undoubtedly result. These facts are cited to illustrate the new and unanticipated demands made on the Survey, which require additional funds if the work now undertaken is to go forward; to say nothing of new lines of work as yet untouched. Similar but less critical conditions obtain in regard to the demands on us for information regarding coal, stone, clay, and other minerals.

It is further true that as the work of the Survey becomes better known and more of the citizens of the State learn the ways in which the office can be useful to them, that larger demands on the time of the members of the force are being made. This may be expected to continue and so, from time to time, either additional funds must be provided or the work deliberately cut down. In the estimate above no provision is made for taking up any new lines of work. If it is desired that any of the many which have been suggested, be taken up, a still larger increase must be made.

2. That the special appropriation of $15,000.00 for the survey of the bottom lands be continued and be made annual. While good progress has been made, it will necessarily be several years before complete plans for the proposed reclamation of these lands can be presented. It is everywhere recognized that surveys are the first step, and that maps are necessary to any satisfactory study of the problems involved, either by the engineer or the financier. These maps are now being made rapidly, accurately, and economically; at a cost, in fact, of but a few cents per acre. If any satisfactory plan of improvement is every to be adopted it can only be on the basis of the study of the whole valley, or even of the comparative study of several valleys. The force is splendidly organized, and the work should go forward without any check until all the data needed for a comprehensive plan of action are at hand. The reclamation of these bottom lands and the regulation of the rivers is one of the big constructive problems of the State. We will never, however, make sure progress with problems of this nature except on the basis of accurate knowledge, and to this end these surveys and the coördinate work of the coöperating State bureaus should be liberally supported.

3. It is recommended that a special appropriation of $7,500 per annum be made to the Geological Commission to provide for preparing and engraving illustrations and maps for printing and binding the reports of the survey; provided that all printing contracts be approved by the State Printer Expert. The law establishing the State Geological Survey requires of it: "The preparation of geological and other necessary maps to illustrate the resources of the State" and "The preparation of reports, with necessary illustrations and maps." It is further provided that: "The regular and special reports of the said bureau shall be printed and distributed or sold, as the commissioners shall deem best." Finally there is the following section with regard to the printing:

"SECTION 6. The printing of said reports and necessary supplies of stationery, blank books and other printed matter necessary for the purpose of said bureau shall be and form a part of the State printing contract, and as such, shall be under the direction and supervision of the Board of Commissioners of State contracts; *provided, however,* that the cost thereof shall not exceed the sum of five thousand dollars ($5,000.00) per annum."

The reports so far issued by the Survey have been printed by the State Printer under the terms of Section 6. Despite, however, the specific provision of the law to the effect that such reports shall include maps and illustrations, the latter have been paid for out of the general support fund of the Survey. At one time the paper upon which the reports were printed was paid for by the Survey. There are probably good reasons for this, and there is no objection from the point of view of the Survey, provided that this expense be taken into account in fixing the appropriations of the latter. As it stands, this constitutes expense of from $1,000 to $2,000 a year, and serves by just so much to decrease the amount originally intended to be made available for the field work of the survey. So far only the most necessary maps have been published, and these have been printed in small editions. No provision has been made for publishing by the State of any of the detailed maps now being made, and much valuable material is therefore unavailable to the general public.

4. It is recommended that hereafter the reports of the Survey be published in the same general style as regards typography, paper, and binding as were the reports of the older Geological Survey of Illinois, and as are now the reports of the State Laboratory of Natural History, and that adequate appropriations be made to the commission to cover the cost of this paper, printing and binding, so that the work may be done promptly. Section 6, quoted above should be repealed in order to relieve the Secretary of State of responsibility.

As matters now stand, even with the Survey paying for all maps and furnishing all engravings to the printer, it has been impossible to get reports printed as fast as they were prepared. There are now seven reports written and ready for the printer, and several more in preparation. Some of these reports have been in hand for more than a year, and yet the Survey has never had the benefit of the maximum amount allowed by law for its printing.

A list of the reports awaiting publication has already been given. All these reports have been written by the best men we could command anywhere in the United States, and each is designed to answer a specific purpose. The field work has been done and paid for and the report has been written, and yet the State has no benefit because of the congestion in the printing office and the defective arrangements already cited.

In addition to the reports enumerated, detailed reports on the geology and mineral resources of the Peoria, Springfield, Belleville-Breese areas have been prepared and material is in hand for a similar report on the southern coal fields from New Haven as far west as Herrin. As each of these reports will require an expensive, engraved map for which the State has made no provision, arrangements have been made for their publication to be undertaken by the Federal Government. It is desirable, if possible, that the State provide at least one edition of these and similar reports for local use.

Studies of the coal, cement, oil and clay industries are being prosecuted, but in the absence of adequate means of publication no attempt has been made to hurry the preparation of reports. None the less, a report on cement materials is practically complete.

These difficulties regarding printing have arisen not because of any lack of coöperation on the part of the various persons concerned, but because the attempt is being made to put out technical publications from plants designed for commercial and ordinary book work, and with facilities entirely inadequate to the demand. A change is imperative, since it is poor policy for the State to spend money on surveys and investigations and then not provide for printing the results promptly and in such form as to be really serviceable to its citizens.

REPORT OF THE CO-OPERATIVE TOPOGRAPHIC SURVEY OF ILLINOIS.

(By W. H. HERRON.)[1]

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1. Geographer in Charge, Central Division, U. S. Geological Survey.

INTRODUCTION.

The act of the State Legislature of 1905 which provided for coöperation between the State of Illinois and the United States Geological Survey in the making of a topographic map of the State has been more than justified by the popular interest in the progress of the work and by the demand for the finished maps. The State was slow in taking this step, but it is believed that the success of the last four years will insure the steady progress of the work until the entire State is surveyed.

Illinois has never had a satisfactory State map, the best at present available being those issued by the General Land Office and the Post Office Department of the Federal Government, together with several popular maps compiled from them, which contain many inaccuracies of latitude and longitude, etc., in the interior part of the State; and while, as a rule they show the system of subdivision of the public land lines, counties, towns, drainage systems, etc., the data for their control is very incomplete and in many cases inaccurate.

It is therefore easy to comprehend the value to the State of the topographic map that is now being prepared in coöperation with the United States Geological Survey, which is utilizing, at an immense saving to the State, the Coast and Geodetic Survey primary triangulation, U. S. Lake triangulation, surveys by the Mississippi River Commission, and the accurate control survey of the Army Engineers along the Illinois river from its mouth to Lake Michigan. The rapid progress and completion of this map will be of inestimable benefit in the study and development of the economic resources of the State, such as minerals, including coal, oil, clay, lead, zinc and cement-making materials. It can also be utilized as a basis for the reclamation of overflowed lands and swamps and their drainage; for the improvement of highways; for a study of water supply for cities, and as a preliminary survey for railways and trolley lines, etc., and for any class of improvements which must take into consideration the configuration of the land surface and quality and character of the soil.

LEGISLATIVE AND ADMINISTRATIVE.

Season of 1905-1906.

In May, 1905, House Bill No. 63 of the General Assembly was adopted, whereby a State Geological Survey was established under the direction of a commission known as the State Geological Commission, and said commission was authorized to arrange with the director or representative

of the United States Geological Survey in regard to coöperation between the United States Geological Survey and the State Geological Commission in the preparation and completion of a contour topographic survey and map or maps of the State of Illinois. The commission was authorized to spend a sum of not more than $10,000 in any one year on this work, provided this sum was met by an equal amount by the Federal Survey.

The following formal agreement was entered into in November, 1905, between the Governor of Illinois and the Director of the United States Geological Survey, confirming a verbal agreement entered into in May, 1905, by which agreement provision was made for the execution of this topographic work:

Agreement between the State Geological Commission of the State of Illinois and the United States Geological Survey for the Execution of the Coöperative Topographic Survey of the State of Illinois as provided for in Act of Legislature of the State of Illinois, 1905.

1. The preparation of the map shall be under the supervision of the director of the United States Geological Survey, who shall determine the methods of survey and map construction.

2. The order in which, in point of priority, different parts of the State shall be surveyed shall be agreed upon in detail by the State Geological Commission of the State of Illinois and the Director of the United States Geological Survey, but in case of failure to agree the order shall be determined by the State Geological Commission.

3. The survey shall be executed in a manner sufficiently elaborate to prepare maps upon a scale of 1:62,500. This map shall exhibit the hydrography, hypsography and public culture, and all township and county boundary lines and extensive wooded areas in this State as existing on the ground at the time of the execution of these surveys. The location of all trails, by-roads, railroads, streams, canals, lakes, rivers, and shall show by contour lines the elevation and depression of the surface of the country.

4. The hypsography shall be shown by contour lines with vertical intervals of 10 or 20 feet, depending upon the scale and relief of the country, and as may hereafter be agreed upon in detail.

5. The heights of the important points shall be determined and furnished to the State Geological Commission of the State of Illinois.

6. The outlines of wooded areas shall be represented upon the proofs of the engraved map to be furnished to the State Geological Commission of the State of Illinois.

7. For convenience, the United States Geological Survey, shall, during the progress of the field work, pay the salaries of the permanent employés engaged thereon, while the traveling, subsistence and field expenss shall be paid for the same time by the State. For official work on the map the salaries shall be divided between the two agreeing parties in such way as to equalize expenses, providing that the total cost to the State of Illinois of the field and office work shall not be more than $10,000 from July, 1905, to June 30, 1906, or for any subsequent fiscal year. And, further, provided, that the United States Geological Survey shall expend an amount upon the same work and during the same period of time.

8. During the progress of field and office work, free access to the records of the topographers shall be afforded the State Geological Commission of the State of Illinois for examination and criticism, and should the Commission consider that the work is not being executed in accordance with this agreement, it may, on formal notice, terminate the same. This agreement may also be terminated by formal notice of either party thirty days prior to the beginning of the new fiscal year.

9. The resulting reports shall fully recognize the coöperation of the State organization.

10. All accounts and vouchers paid by the State Geological Commission under this agreement shall be subject to their auditing and approval.

11. It is further agreed that, in view of the coöperation arrangements here entered into, the State Geological Commission of the State of Illinois shall be furnished with transfers ,at the cost of printing, from the copper plates, for use in printing editions of said maps by the State.

(Signed) Chas. D. Walcott,
Director U. S. Geological Survey.

Washington, D. C., November 20, 1905.

(Signed) Charles S. Deneen,
Chairman State Geological Commission, State of Illinois.

Springfield, Ill., November 17, 1905.

RESULTS.

From the expenditure of the joint fund of $20,000 provided for in the above agreement, a complete and accurate map was made for publication on the scale of 1:62500, with contour intervals of 10 and 20 feet, of 1,347 square miles of the State, which is represented on the following six sheets: Belleville, in Madison and St. Clair counties; Eldorado, in Gallatin, Hamilton, Saline and White counties; Mahomet, in Champaign and Piatt counties; New Haven (Ill., Ind., Ky.) in Gallatin and White counties; Springfield, in Logan, Menard and Sangamon counties; Urbana, in Champaign county. In addition, eighty-three square miles were mapped over the edges of these sheets, which will be incorporated in future map work.

Considerable preliminary work was accomplished on the following quadrangles: Breese, in Bond, Clinton; St. Clair and Madison counties; Carmi, (Ill., Ind.) in White county; Havana, in Fulton and Mason counties; Petersburg, in Logan, Menard and Sangamon counties; Saidora, in Cass, Fulton, Mason and Schuyler counties; Wheaton, in DuPage county. Of these the Breese and Wheaton quadrangles were about half surveyed.

During the season there were run on all of the above eleven sheets 3,740 miles of spirit levels, in the course of which 24,446 elevations and 101 permanent bench marks were established; there were run 6,223 linear miles of road traverse, every bend and every house being accurately located.

Two parties extended primary traverse over the counties of Champaign, Clinton, DuPage, Madison, Menard, St. Clair and Sangamon, resulting in the occupation of 1,441 stations and the running of 402 miles of traverse. One party extended precise levels over the counties of Champaign, DeWitt, McLean, Piatt and Tazewell, resulting in the running of eighty-seven miles, in the course of which thirty-three permanent bench marks were established.

Season of 1906-1907.

The coöperative agreement signed by the Governor of the State of Illinois and the Director of the United States Geological Survey in

November, 1905, was continued for the coöperative topographic survey of the State for the fiscal year ending June 30, 1907, in the following supplemental agreement:

Supplemental Agreement between the State Geological Commission of the State of Illinois and the Director of the United States Geological Survey for the continuation of the Coöperative Topographic Survey of Illinois, for the Fiscal Year Ending June 30, 1907.

In accordance with the provisions of an agreement between the above named parties, signed November, 1905, the terms of which are hereby extended for the continuation of this coöperative surveying, it is further agreed and understood that the State of Illinois shall expend for such coöperative surveys during the fiscal year ending June 30, 1907, a sum of not less than $10,000; *provided*, that the United States Geological Survey shall expend for coöperative topographic surveys within the State an amount at least equal to the above.

(Signed) CHAS. D. WALCOTT,
Director U. S. Geological Survey.

(Signed) C. S. DENEEN,
Chairman State Geological Commission, State of Illinois.

RESULTS.

Correspondence was immediately entered into between the Director of the State Geological Survey, Dr. H. Foster Bain, and Mr. H. M. Wilson, Geographer, of the U. S. Geological Survey, in which plans were perfected for the work to be executed during the year, and such plans were carried to completion.

From the expenditure of funds provided for in the supplemental agreement an accurate map was made for publication on the scale of 1:62,500, with contour intervals of 10 and 20 feet, of an area of 1,055 square miles of the State, which is represented on the following five sheets, namely: Breese, in Bond, Clinton, Madison and St. Clair counties; Galatia, in Franklin, Hamilton, Saline and Williamson counties; Waukegan, (Ill., Wis.), in Lake county; Wheaton, in Cook and DuPage counties; Tallula, in Cass, Menard, Morgan and Sangamon counties. This latter quadrangle was completed with the exception of thirteen miles. In addition, ninety square miles were mapped over the sheet edges, which will be incorporated in future map work. Considerable preliminary work was accomplished on the following quadrangles: Galena, (Ill., Ia.), in Jo Daviess county; Thompsonville, in Franklin and Williamson counties; Herrin, in Franklin, Jackson, Perry and Williamson counties.

During the season, for the control of the above quadrangles, 2,464 miles of spirit levels were run, in connection with which sixty-six permanent marks and 15,771 useful elevations were established. There were also run 3,227 miles of road traverse, upon which all bends and houses were accurately located.

One party extended primary traverse over portions of the counties of Franklin, Hamilton, Jackson, Jo Daviess, Perry, Lake, Saline, Williamson, which will furnish geodetic positions of a great many points to which to tie future topographic and property surveys. This work resulted in the occupation of 1,671 stations and the running of 398 miles

of traverse. One party extended precise levels over portions of the counties of Coles, Cumberland, Douglas, Edgar, Franklin, Gallatin, Jasper, Richland, Saline, and Vermilion, 206 miles of double line being run, in connection with which seventy-six permanent bench marks and 435 elevations were established. These furnish exact heights through which to refer to mean sea level any spirit leveling which may be done hereafter by private or public organizations.

Owing to the late date at which it was possible to resume field work, namely, after the first week in July, because neither State nor Federal funds were available until July 1st, the field season was unusually short, but the progress was as good as could have been anticipated.

Three of the topographic sheets mapped during the previous year were engraved, namely; Urbana, New Haven and Eldorado, copies of which are sold by the U. S. Geological Survey at the nominal price of five cents per copy.

Season of 1907-1908.

The agreement of November, 1905, for coöperative topographic surveys was further continued by a supplemental agreement similar to that of the year before, the amount provided by the State, however, being $8,000, to be met by a like sum from the United States.

RESULTS.

From the expenditure of the $16,000 provided for coöperative topographic work, the survey of the Tallula quadrangle, in Morgan, Sangamon, Cass and Menard counties, and the West Frankfort quadrangle, in Franklin and Williamson counties, was completed; and the survey of the Carlyle, New Athens and Okawville quadrangles, in St. Clair, Washington, Clinton and Bond counties; the Hardinville quadrangle, in Jasper, Crawford, Richland and Lawrence counties; and the Herrin quadrangle, in Jackson, Perry, Franklin and Williamson counties, was commenced. The total area surveyed was 624 square miles, for publication on the scale of 1:62,500, with a contour interval of twenty feet. For the control of these and adjacent areas 477 miles of primary and 2,636 miles of secondary levels were run and 108 permanent bench marks were established. The Carlyle, Chauncey, Okawville and New Athens quadrangles, in Clinton, Richland, Lawrence, Jasper, St. Clair, Washington and Monroe counties, were controlled by 237 miles of primary traverse run and 913 stations established. A line of precise levels thirty-two miles in length, extending from the vicinity of Terre Haute, Ind., to Oakland, Ill., through the Paris and Kansas quadrangles, in Edgar and Coles counties, was also run, in connection with which twelve permanent bench marks were established.

Of the topographic sheets mapped during the season of 1906-1907, the Breese was engraved.

Season of 1908-1909.

The agreement of November, 1905, for coöperative topographic surveys was continued by a supplemental agreement similar to that of 1906-1907, which provided for the mutual expenditure of $8,000 by the State of Illinois and the United States Geological Survey.

RESULTS.

From the expenditure of the $16,000 available for topographic work, the survey of the Carlyle quadrangle, in Clinton and Bond counties; the Herrin quadrangle, in Jackson, Perry, Franklin and Williamson counties; the Murphysboro quadrangle, in Jackson and Perry counties; the Okawville quadrangle, in Clinton, Washington and St. Clair counties; and the Hardinville quadrangle, in Crawford, Lawrence and Jasper counties was completed; and the Survey of the Vandalia quadrangle, in Fayette county; the Baldwin quadrangle, in Randolph county; and the New Athens quadrangle, in St. Clair and Monroe counties, was commenced, the total area mapped to December 31, 1908, being 915 square miles, for publication on the scale of 1:62,500, with a contour interval of twenty feet. Preliminary work was well advanced on the Apple River and Galena quadrangles, in Jo Daviess county; the Baldwin quadrangle, in Randolph county; the LaSalle quadrangle, in LaSalle, Bureau, and Putnam counties; the Bridgeport quadrangle, in Lawrence and Wabash counties; the Hennepin quadrangle, in Putnam, Bureau and LaSalle counties, and the Carmi quadrangle, in White and Posey counties. All control for the New Athens quadrangle was completed.

For the control of the above quadrangles and adjacent areas 542 miles of primary levels, 1,849 miles of secondary levels, 344 miles of primary traverse, and 4,033 miles of secondary traverse were run, and 118 permanent bench marks were established.

Of the quadrangles previously mapped, the Galatia, Waukegan and Wheaton were engraved.

Expenditures.

Since the inauguration of topographic surveys in 1905, to the close of the fiscal year 1908-1909, there were available for coöperative topographic surveys from State and Federal funds $72,000. Of this amount there had been expended on December 31, 1908, $70,462.39, leaving a balance of $1,537.61. This balance was reserved in accordance with the agreement in order to meet the permanent salaries of civil service employés engaged in completing the drafting of the topographic maps, and to prosecute surveys in the field during the good spring weather.

Resume of Results.

During the time that coöperative topographic surveys have been in progress, seventeen whole and three partial quadrangles have been completed, comprising an area of 3,941 square miles, in addition to which about 425 square miles over sheet edges have been mapped, at a total

expenditure of $57,462, which includes the cost of primary triangulation and precise levels. In addition to this a large amount of preliminary control has been completed preparatory to future topographic mapping at a cost of $14,538.

The following tabular statement gives the names of the sheets completed during the four years coöperation, their areas, scale, contour interval and the year mapped:

TOPOGRAPHIC ATLAS SHEETS MAPPED IN CO-OPERATION.

Quadrangle.	Area Mapped.	Year.	Contour Interval.	Scale.
	Sq. miles.		Feet.	
Belleville	233.28	1905	20	1.62500
Eldorado	235.66	1905	20	1.62500
Mahomet	228.40	1905	20	1.62500
New Haven (Ill., Ind., Ky.)	192.78	1905	20	1.62500
Springfield	229.22	1905	10	1.62500
Urbana	228.40	1905	10	1.62500
Breese	233.28	1906	20	1.62500
Galatia	235.66	1906	20	1.62500
Waukegan (Ill., Wis.)	149.00	1906	20	1.62500
Wheaton	225.50	1906	20	1.62500
Tallula	229.22	1906	20	1.62500
Herrin	235.66	1907	20	1.62500
West Frankfort	235.66	1907	20	1.62500
Carlyle	233.28	1908	20	1.62500
Murphysboro	235.66	1908	20	1.62500
Okawville	234.07	1908	20	1.62500
Hardinville	232.48	1908	20	1.62500
Vandalia[1]	64.00[1]	1908	20	1.62500
New Athens[1]	35.00[1]	1908	20	1.62500
Baldwin[1]	15.00[1]	1908	20	1.62500
Total	3,941.21			

[1] Only partially completed.

Nature of Co-Operation.

The coöperative topographic survey of the State has been vigorously prosecuted during the past four years in accordance with the joint agreements above cited. Under the terms of these agreements, the execution of the work both in field and office is under the immediate charge of the Federal Survey, which draws upon the large corps of trained topographers which has been created under it through the Federal Civil Service. The Director of the State Geological Survey recommends the order, in point of priority, in which the different parts of the State shall be mapped, as he is best acquainted with the needs of the State in this direction. Many of the citizens of the State who are competent engineers have found employment upon this work.

When the Legislature made its appropriation for beginning this work in 1905, the Federal Survey had made rough reconnaissance maps in many cases, and in a few cases more detailed and accurate topographic maps of a total area of 4,917 square miles of the State. These have been published by the Government upon thirty-nine separate atlas sheets distributed throughout various parts of the State, upon which it had independently expended a sum roughly estimated at $40,000 between the

years 1887 and 1904, inclusive. A large portion of this work is on the scale of about two miles to one inch, with contours showing elevations for change of every fifty feet in altitude. Some of it is on the larger scale of one mile to one inch, with contour intervals of twenty and ten feet. A considerable portion of this area was mapped before the Federal Survey began its more accurate work and is lacking in detail, no houses being represented. It is also devoid of spirit leveling, so that the contouring and elevations are not sufficiently reliable to afford a basis for exact engineering work.

The land area of Illinois is 56,002 square miles and the water area 663 square miles, making a total of 56,665 square miles. There have been mapped in coöperation 3,941 square miles, and prior to coöperation 4,917 square miles, a total of 8,858 square miles, leaving 47,807 square miles yet to be mapped, though 3,000 square miles of the earlier reconnaissance work should be added to this area, as it will ultimately be resurveyed.

Objects and Recommendations.

As stated, the object of making a topographic survey of the State in such great detail as will permit the making of a map on the scale of one mile to one inch, is primarily to serve as a basis for study of the structural and economic geology of the State, with a view to aiding in the development of its economic mineral resources. In 1908 Illinois ranked second among the states in quantity of coal produced, the amount being 47,659,690 short tons of a value of $49,978,247. It ranked well up in the production of building stone and cement-making materials. It is believed that the output of many of the minerals found in the State may be increased through the medium of this survey. These maps have a high value in connection with all studies for drainage of swamp and overflowed lands. They show the positions of the swamps, the absolute heights of points upon them, and the relation of these in altitude to the stream channels through which they may be drained. They are of especial value to the State in connection with studies for the improvement of highways. They are needed in connection with the planning of public improvements, developing railways, trolley lines, etc.

At the close of December, 1908, 8,858 square miles had been mapped, leaving approximately 50,000 square miles to be mapped or resurveyed. In order that this work may be continued, now that it has been so auspiciously commenced, $10,000 should be appropriated each year for the completion of the topographic survey of the State.

Organization and Reports.

Topographic mapping in Illinois is under the general direction of Mr. R. B. Marshall, Chief Geographer, of the United States Geological Survey, and under the immediate direction of Mr. W. H. Herron, Geographer in Charge of the Central Division, who has personal supervision of the field work and is held responsible for its quality and organization. Mr. E. M. Douglas, Geographer, has charge of the section of primary

control and precise leveling and overlooks the office computations. Under Mr. Herron several topographers, named in the body of this report, had charge of field parties, assisted by temporary aids employed for the season only. All of the men excepting the temporary employés are U. S. Civil Service appointees who have passed a rigid engineering examination. The temporary employés are selected preferably from residents of the State and fill out applications accompanied by letters of recommendation showing their education, experience, and other qualifications for this special line of work. The field work is further inspected by Mr. J. H. Renshawe, Inspector, and by the Director of the State Geological Survey.

Weekly reports of progress are sent to the party chiefs, and monthly reports are submitted by the party to the Division Chief and the Chief Geographer, the latter of whom transmits them with a financial statement to the State Geological Survey.

Fiscal System.

The salaries of the party chiefs are fixed by appointment from the Honorable, the Secretary of the Interior, while the salaries of the temporary aids are determined by the qualifications shown in their applications and by promotion subsequent to employment. All actual traveling expenses are refunded upon presentation of vouchers duly signed and sworn to, and per diem in lieu of subsistence is allowed, the same ranging from $1.50 to $2.25, according to the location of the work and the nature of the duties assigned to the employés. All vouchers are submitted semi-monthly in duplicate to the division chief, who after approving them transmits a portion to the Federal disbursing officers for payment and another portion through the Director of the State Geological Survey to the State Auditor for payment. A monthly statement transmitted to the Director of the State Geological Survey itemizing the amount expended by the Federal Government. The conditions of the agreement are such that the State Survey expends the bulk of its funds during the summer season on actual field work and the Federal Government pays the permanent salaries. In consequence the Federal Government does not expend nearly so much as the State by the close of the season, having to reserve a sufficient sum to cover office salaries on drafting and computing.

NATURE AND USES OF TOPOGRAPHIC MAPS.

General Plan.

The topographic maps made under this coöperative arrangement are drawn up in the office in three colors and furnish exact copy for reproduction. The published maps are engraved in the office of the Federal Survey in Washington on three separate copper plates, on one of which is shown the drainage and water surfaces, and on a second, all roads, houses, names and other cultural features, and on the third, figures of elevation and shapes and heights of hills by contour lines. The map is printed from transfers from these three copper plates to three lithographic stones, in blue, for the water features; black for the cultural features; and brown, for the topographic relief of the surface. The result is a very handsome and attractive and extremely legible map, the neat size of which is about 17½ inches by 13 inches wide.

For purposes of convenient publication, and in order that the edges of adjoining sheets may match and be mounted together in larger groups, the whole area of the country is divided by latitudes and longitudes fifteen minutes each way to a map sheet, so that each map represents one quarter of a square degree, or an area in Illinois of approximately 225 square miles to an atlas sheet. To cover the entire State several hundred such atlas sheets will be required to make the final map which, extending from latitude 37° 00′ to latitude 42° 30′ will be 355 inches long north and south, and 240 inches long east and west. Upon this map when finally completed there will be located many thousands of geodetic positions, or an average of one to every twenty square miles, and a still greater number of permanent bench marks showing precise level elevations above sea, these averaging about two to each township. The latter will be of inestimable value as datum upon which to base all engineering projects, and the former will serve as permanent bases for all future cadastral or property and political surveys.

Surveying in general may be divided into three classes:

1. Those made for general purposes, or information surveys, which may be exploratory, geodetic, geographic, topographic, geologic, etc.
2. Those made for jurisdictional purposes, or cadastral surveys, which define political boundaries and those of private property and determine the enclosed areas.
3. Those made for construction purposes, or engineering surveys, on which are based estimates of the cost of public and private works, such as canals, railways, water supplies, etc., and their construction and improvement.

The topographic survey, one of those in the first class, is made for military, industrial, and scientific purposes. The topographic map, made directly from nature by measurements and sketches on the ground,

is the mother map from which all others are derived. It shows with accuracy all the drainage, relief and cultural features which it is practicable to represent on the scale chosen.

The features exhibited on the maps are:

1. Hydrography, or water features, as ponds, streams, lakes, swamps, etc., which are printed in blue.
2. Hypsography, or relief of surface, as hills, valleys, and plains, which are printed in brown.
3. Culture, or features constructed by man, as cities, roads, villages, and the names of boundaries, which are printed in black.

This combination of color renders these topographic maps readily legible. On the reverse side of each sheet is a description of the mode of reading the map, and a legend, or series of conventional signs, indicating how the various facts shown on the maps are represented. All these conventions are self-explanatory and are readily understood and interpreted by the layman, except, perhaps, the brown "contour" lines.

These contour lines are of equal elevation—lines along which the ground would be touched by the border of a water surface (of the ocean, for instance) if it were repeatedly raised by a given amount. Contour lines express three features of relief: (1) elevation; (2) horizontal form, and (3) grade or slope. To explain more clearly the manner in which the contours shown on the maps of the Geological Survey delineate height, form and slope, the accompanying contour map (Fig. 1) has been prepared from the ideal view shown above it. It may be interpreted as follows:

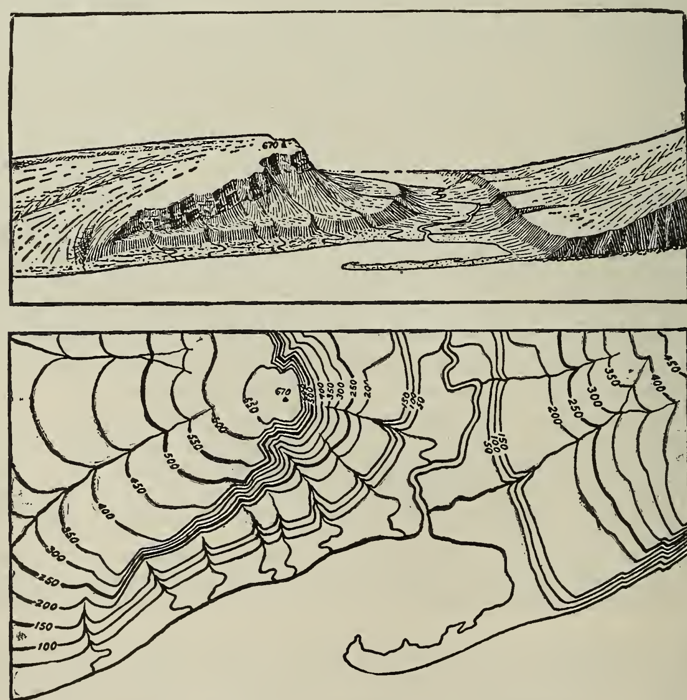

FIG. 1—Ideal view and corresponding contour map.

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore, the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the 250-foot contour lie all points of the surface 250 feet above sea; along the 200-foot contour, all points that are 200 feet above sea, and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore, all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say, every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

2. Contours define the horizontal forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all re-entrant angles of ravines, and project in passing about prominences. These relations of contour curves and angles to forms of the landscape can be traced in the map and view.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope, one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

Publication.

While the Federal Survey coöperates with the State in making the field survey and drafting the resulting map, it undertakes alone the publication of the final results. In consequence, though the State contributes half toward the making of the survey, one of the most expensive features of the map making, the publication and distribution, is handled at no expense to the State. Meantime, since the inception of coöperation the State has benefitted by marked improvements in the method and style of the published maps, the character of the lettering and other finish of the engraving making the maps more attractive and legible. Much greater detail and nicer representation is shown on the later maps than on the earlier ones. This includes chiefly, exactness in representing cuts and fills and other obstacles along railroads and highways; the position of the highest point on hill and mountain tops. Not only are all houses in cities and in the country shown, but school houses and churches are distinguished, as are cemeteries.

Scale and Contour Interval.

The scale selected for the coöperative maps is that adopted for the whole of the United States, which is being mapped upon two standard scales, one of about two miles to one inch, and the other of about one mile to an inch. This latter and larger scale is adopted for Illinois, the exact multiple being represented by the figures 1:62,500, which is an aliquot part of 1:1,000,000, the international scale adopted by all great organizations throughout the world, as well as by the Coast and Geodetic Survey and the War Department of the Federal Government. The

actual field scale is 4,000 feet to 1 inch, which is reduced in publication. In regions of special importance, as about large cities, the field work of surveying is done on double this scale, or on the scale of 2,000 feet to 1 inch, though no arrangements for publishing on this larger scale have yet been made by the Federal Government.

The contour interval adopted is 10 or 20 feet according to the steepness and amount of relief or comparative flatness of the slopes. Which of these two contour intervals shall be used is agreed upon in detail each year by the coöperative officials; the maps about Urbana, where the country is quite level, having been mapped with the 10-foot interval, while the maps about Eldorado and Belleville, where the country is more deeply eroded were mapped on the 20-foot interval. The scale selected is so large that a distance of about 100 feet on the ground, can be represented on the map, thus permitting the actual platting of every house and every bend in the road, etc. The contour interval is such that every change in the slope and every difference in elevation amounting to 10 and 20 feet can be accurately represented.

Areas of Political Subdivisions.

The result of this topographic mapping is to show accurately for the first time the boundaries of all townships and counties so far as the data can be procured in the field and from county records. This survey is not warranted in investigating questions of disputed boundaries or of obscure boundaries. These are matters for determination by the courts. The boundaries as found and shown on the maps present clearly and accurately all questions connected with the townships and counties; show in which township and county fall various roads, houses, etc., and furnish the data from which to make an exact measurement of the areas of these political subdivisions.

The system of symbols, and particularly the contour system by which elevations and slopes of these maps are shown has been adopted by the Federal Survey after much careful thought.

Uses of the Maps.

It is evident from the foregoing that the uses of the maps are so varied as to furnish data touching nearly every public and private activity having to do with the surface of the land.

Some of the special uses of the maps to the State are as follows:

1. As preliminary maps for planning extensive irrigation and drainage projects, showing areas of catchment for water supply, sites for reservoirs, routes of canals, etc.
2. Highways, electric roads, railroads, aqueducts and sewerage systems may be laid out on them, thus saving the cost of preliminary surveys.
3. In the improvement of rivers and smaller waterways.
4. In the determination and classification of water resources, both surface and underground.
5. By boards of health in the disposal of city sewage, garbage, etc.
6. In determining routes, mileage, location of road-building material, and the topography in country traversed by public highways.

7. In the selection of most practical routes for automobiling tours and inter-city runs.

8. As a guide map for prospectors and others in traveling through little-known regions.

9. As a base for the compilation of the extent and character of forest and grazing lands.

10. In the classification of lands and in plotting the distribution and nature of the various soils.

11. In the compilation of maps in connection with the survey and sale of lands.

12. In investigations for the improvement of the plant and animal industries, and in a comprehensive study of physical and biological conditions in connection with the stocking of interior waters with food fishes, and in advantageously locating fish-culture stations.

13. In locating and mapping the boundaries of the life and crop zones, and in mapping the geographical distribution of plants and animals.

14. In plotting the distribution and spread of injurious insects and germs.

15. As a base map for the plotting of information relating to geology and the mineral resources of the country.

16. In maneuvers of the national guard, in the development of military problems, and in the selection of routes for road marches or strategical movements of the troops, particularly of artillery or cavalry.

17. In connection with questions relating to State, county or town boundaries.

18. As a means of promoting an exact knowledge of the country and serving teachers and pupils in geographic studies.

19. As base maps for the graphic representation of all facts relating to population, industries, products, or other statistical information.

20. In connection with legislation involving the granting of charters, rights, etc., when a physical knowledge of the country may be desirable or necessary.

21. Their main importance, however, is as a basis upon which to study the geological formations and the relations of the various coal, oil and gas-bearing formations one to another, their depth below the surface and the probable extension of such resources into unexploited areas, also as a basis for soil surveys for the determination of the agricultural value and properties of the lands.

TOPOGRAPHIC MAPPING OF BOTTOM LANDS.

The last General Assembly of Illinois made a small appropriation for the beginning of surveys and studies of the over-flow lands of the State, for the purpose of acquiring a knowledge of their exsiting conditions, and the methods by which the needed improvements may best be made. In accordance with this legislation, the State Geological Survey last year began the topographic mapping of portions of the Kaskaskia, Big Muddy and Embarass rivers, in which it coöperated with the topographic branch of the U. S. Geological Survey. Coöperative topograhic mapping having been arranged in quadrangles adjacent to these streams, much of the control work of the regular surveys, has, with slight modifications been utilized for our special drainage work. This has enabled us, at the least possible expense, to produce during the past season a 5-ft. topographic map on a scale of 1:24000 of approximately 200 square miles of these river bottoms.

The purpose of the survey in doing this work along the river courses is to furnish a detailed topographic map, sufficiently accurate to be of practical value to the engineer in the planning of any proposed improvements and the estimating of costs for same. While the question of the scale has been somewhat perplexing, it is believed that the 1:24000 scale will prove adequate for the uses for which it is intended, since it is sufficiently large to contain all detail that would be taken into account in the planning of these improvements. It has the additional advantage of permitting large sections of the country to be mapped on a single sheet of paper, thereby presenting in a collected form the conditions in different sections of the bottoms. Also because of its much reduced cost, which must be considered with a limited appropriation, it has a very strong claim to consideration.

The section of country especially referred to here, and which may be considered in a general way as representative of the over-flow lands, is that portion of the Kaskaskia river bottoms mapped last year, extending from Keyesport on the northern boundary of Clinton county to its outlet near Chester. Within this area, the field work has been completed south to near the boundary line between Clinton and St. Clair counties, including a total of 160 square miles, while the level and traverse work has been completed for the remaining portion to the mouth. Of the 160 square miles of mapped country, 130 square miles are under from 1 ft. to 8 ft. of water several times each year. The overflow season usually begins in January, and at times lasts as late as the middle of August,

which makes the season, in which the land is dry enough for cultivation, entirely too short for successful farming. It seems to be generally necessary to plant several times each spring, and even with the last planting farmers cannot hope for a yield to the full capacity of the land. It has been stated that a successful crop, one that has escaped damage by the flood, does not occur oftener than once in seven years. In fact, so completely is this river in possession of its bottom lands that very little effort is made to utilize it in any way, and at the present time it might well be considered waste land.

In making a study of these rivers, it is well to bear in mind that their present condition is not altogether due to natural causes, but that the making of drainage improvements in other parts of the State, is to a great extent responsible for their present trouble. More than 25 years ago, after a practicable demonstration of the successful drainage of farm lands by tiling, the central part of the State began an earnest and persistent fight for the reclamation of their swamp and wet areas. The vital question of sufficient outlet naturally followed, and by individual effort, by the formation of drainage districts, and with other help, canals were dredged and natural channels straightened and improved. These, with innumerable ditches of smaller capacity, now quite thoroughly provide for the disposition of the water from tiled fields. This quarter of a century of sustained effort on the part of the farmers of the State, during which millions of dollars have been spent on drainage propositions, has resulted in a most thorough system of successful drained farm lands. So thoroughly has this work been accomplished that it might be said that Illinois, with the exception of a few areas, such as the Kankakee Marsh, and the Green river country, has reached almost the last stages of a complete drainage system for the State. Important exceptions also, are some of the rivers, part of which form its boundaries. This final step, however, presents by far the greatest problems for the engineer, and their successful solution can be obtained only after a very thorough examination of all conditions which bear upon the question. The localities now needing outlet are to be found in the lower stretches of the principal streams of the State, the Kaskaskia, Little Wabash, Big Muddy, Embarass and Sangamon being especially important.

Before the uplands were reclaimed by tiled drains, a rainy season of even a week's duration, produced but a slight increase in the flow of the channels of these streams. This was due to the fact that the rain collected in enormous areas of marsh and lowlands, and reached these river courses by a very slow and tedious process. The experience of the past summer, while making topographic surveys along the Kaskaskia river, shows that a rain of 24 hours will now raise the stream from 4 to 10 feet. An explanation of this is readily found in the fact that with our present system of tile drainage and the excellent outlets thereto, water from such a rain is carried quickly from the fields and poured immediately into the upper courses of these streams, and the multiplication of these feeders has forced upon the streams a burden entirely beyond their present capacity. As a result the numerous floods have rendered thousands of acres of the best farming land of the State practically worthless.

It will be easily seen that the responsibility for the improvement of the channels of these rivers rests equally upon the farm holders on the upper courses of these rivers and those located nearer their outlet. The principle of general assessment, so thoroughly recognized in legislation providing for drainage districts, can be applied with justice to these larger problems of reclamation which cover all land within individual drainage basins.

The methods used in making these drainage maps are very similar to those of the topographic branch of the U. S. Geological Survey, the principle difference being that because of the contour interval used the enlarged scale, and the object of the work itself, a greater amount of detailed work is necessary. As bases for our maps we have the primary traverse transit lines of the U. S. Geological Survey for position and the primary level lines of the same survey for elevation, in addition to which we have the steel tape measurements along township lines. With these lines for control, a plane table buggy traverse is run of the first ridge road outside the bottom on each side of the river, and as often as possible cross roads, which tie the work together, are run in the same way Since the distance between roads crossing the river is so great, it has been found necessary, at intervals of from 1½ to 2 miles, to traverse from the outside roads to the river, where points are left for the purpose of being tied to by the stadia traverse of the river. While the wheel method of measurement may be considered crude and inaccurate, a practical test will prove that for scales even longer than the one used in this work and controlled equally well, it will fully meet all requirements. The accumulation error is slight, and when larger errors are made, they are readily located after the traverse has ben tied to itself or to another line.

Over the same roads, and others when necessary, spirit levels are run and numerous elevations painted at summits, bridges, road corners and other convenient points, while at intervals scarcely exceeding a quarter mile, substantial bench marks are left. The level work is so planned that elevations determined by stadia, need not be carried for distances greater than 1½ miles. Experience during the past summer indicates that levels may be successfully carried with this instrument for distances of 3 or 4 miles. The instrument used is similar to the ordinary stadia, except that it is provided with an attachment which simplifies the reading of elevations at an angle. It has been in use on the U. S. Geological Survey the last few years, the idea for the improvement having originated with members of that survey.

The frame work of traverse and level lines, together with the stadia traverse of the river and other streams, is adjusted to the land lines and the other available control after which it is ready for the topographer. This topographic sketching is by far the most difficult work connected with the making of a map, because the necessity of carrying innumerable stadia lines through the dense jungles of the bottoms. Starting from convenient bench marks, these lines zig-zag through the bottoms, the sight being through the openings of greatest length in the general directions of the traverse. The importance of these lines being closely run is clearly shown by a glance at the finished map, for the great number of

lakes, sloughs, marshes and isolated hills are features that can not be reliably mapped except by actual survey. Being hidden, as they are, by dense woods they must be hunted, and the meandering traverse line is the method by which we find them.

On our drainage maps, such features have been carefully traversed and their elevation determined, and in addition to the numerous cross sections at short intervals, a mass of isolated elevations have been left throughout the bottom lands. These stadia lines, as carried through the bottoms, are usually run with great difficulty because of the heavy undergrowth, and especially is this true in mid-summer, when, in addition to the dense foliage, the intense heat and mosquitoes make work both difficult and disagreeable. In fact, because of this condition in the bottoms, the problem of keeping help is a very serious one and the best solution seems to be in the bringing of help from such a distance that quitting at will is made more difficult. Few men will submit long to the physical sufferings met with in the bottoms, even at wages two to three times the price they can receive elsewhere, if they are where they can reach home within a few hours.

Along with the stadia traverse and levels, the relief of the river bottoms and the country adjoining the bottom lands has been carefully sketched. This map of the relief with 5 feet contours should greatly facilitate the study of the river problem. Mere location of the stream course and elevations, be they ever so numerous, does not bring to the eye of the engineer the actual figuration of the surface. It is thought that it will be necessary to inspect most minutely the local physiographic conditions before a successful plan of improvement can be determined. It has been planned, therefore, to present to the engineer who studies this great problem the most complete possible data for his use. It is not claimed that this form of map is the most inexpensive one even under favorable conditions under which it was accomplished last season, but it is believed that in the end it will justify itself on the ground of economy in the saving of time and of additional work for the engineer. It also seems that in a study of the carrying capacity of the channel, the effect of possible dike construction and of the control of lateral streams, the topographic features of the map will appeal very strongly to the engineer.

PROGRESS OF TOPOGRAPHIC SURVEYS IN ILLINOIS PRIOR TO CO-OPERATION.

In 1887 the United States Geological Survey did its first work in topographic mapping in Illinois. This work was continued thereafter for several years with considerable energy, chiefly along the course of the Illinois river. This surveying was undertaken with a view to aiding the study of the Drainage Commission of Chicago in solving the problem with which it was charged, and included the making of a series of fifteen maps extending from Chicago via Joliet and Hennepin to Peoria, and covering an area of approximately 3,700 square miles. Other topographic mapping was done in the neighborhood of East St. Louis, and in the northwestern corner of the State in connection with studies of mineral resources in the neighborhood of Jo Daviess county. There were thus mapped in the seventeen years prior to coöperation 4,917 square miles without the assistance of the State, or at the average rate of nearly 300 square miles a year. It is evident that ot this rate many years must pass before the survey of the State will be completed. With coöperation appropriated for at the rate of $10,000 per annum, there have been mapped 2,492 square miles, or at the rate of 1,246 square miles per annum. At an increased rate of appropriation there would be an increased output. The topographic mapping done prior to coöperation is estimated to have averaged $8.00 per square mile. The total expenditure on this work by the Federal Government alone and unaided has therefore been about $39,336.

1887.—The first topographic surveying prosecuted by the United States Geological Survey in Illinois was in connection with the mapping of the Louisiana (Mo.-Ill.) sheet, in Pike county, for publication on the scale of 1:125,000, with 50-foot contour interval. The work was done by Mr. H. L. Baldwin, topographer.

1888.—During this year Mr. Baldwin completed the survey of the St. Louis (Mo.-Ill.) sheet, in Madison, St. Clair and Monroe counties, for publication on scale of 1:62,500, with 20-foot contour interval. This sheet was resurveyed in 1903 to bring the culture up to date of the Louisiana Purchase Exposition.

1889.—The Calumet (Ill.-Ind.) sheet, in Cook county, was mapped by Messrs. D. C. Harrison and R. C. McKinney. This sheet was published in 1901 after having been revised for cultural changes. The Chicago sheet, in Cook county, was mapped in this year and revised for publication in 1897 and 1899. The topographic field work was done by Messrs. D. C. Harrison, N. Tyler, Jr., and R. C. McKinney, topographers, together with the Chicago Sanitary Commission. The Davenport (Ia.-Ill.) sheet, in Rock Island county, was mapped by Mr.

W. J. Peters, topographer. It has since been reduced and forms part of the Rock Island (Ia.-Ill.) sheet, on scale of 1:125,000. The above work was all for publication on the scale of 1:62,500 with contour intervals of 5 to 20 feet respectively.

1890.—The Clinton (Ia.-Ill.) sheet, in Carroll and Whiteside counties, was mapped by Messrs. W. J. Peters and R. C. McKinney, topographers, and was revised in 1896. This was on the publication scale of 1:62,500, with a contour interval of ten feet. The DesPlaines sheet, in DuPage, Cook and Will counties, was completed by Messrs. D. C. Harrison and N. Tyler, Jr., and the Chicago Sanitary Commission. It was revised in 1899 for publication on the scale of 1:62,500, with contour interval of 10 feet. Goose Lake (Ia.-Ill.) sheet, in Rock Island county, was mapped by Mr. W. J. Peters, topographer. It now forms a part of the Cordova (Ia.-Ill.) 1:125,000, sheet, though it was originally for publication on the 1:62,500 scale with contour interval of 20 feet. Joliet sheet, in Cook, DuPage and Will counties, was mapped by Mr. D. C. Harrison, topographer, on the 1:62,500 scale with contour interval of 10 feet. The Leclair (Ia.-Ill.) sheet, in Rock Island county, was mapped by Mr. W. J. Peters, topographer. It also forms a part of the Cordova thirty-minute sheet, and is published on the 1:62,500 scale, with contour interval of 20 feet. The Marseilles sheet, in La Salle, Grundy and Kendall counties, was completed by Mr. D. C. Harrison, for publication on the scale of 1:62,500, with contour interval of 10 feet. The Morris sheet, in Kendall and Grundy counties, was also mapped by Mr. Harrison on the same scale and with the same contour interval. The Ottawa sheet, in LaSalle county, was mapped by Mr. Harrison on the same scale and with the same contour interval. The Peosta (Ia.-Ill.) sheet, in Jo Daviess county, was mapped by Mr. W. J. Peters, topographer, and was revised for publication in 1896. This was on the publication scale of 1:125,000, with a contour interval of 20 feet. The Riverside sheet, in Cook and DuPage counties, was mapped by Messrs. D. C. Harrison, N. Tyler, Jr., and the Chicago Sanitary Commission, and was revised for publication in 1899, scale 1:62,500, contour interval 10 feet. Savanna (Ia.-Ill.) sheet, in Jo Daviess and Carroll counties, was mapped for publication on the scale of 1:62,500, with contour interval of 20 feet, by Mr. W. J. Peters, topographer. The Wilmington sheet, in Will county, was mapped by Mr. D. C. Harrison, for publication on the scale of 1:62,500, with a contour interval of 10 feet.

1891.—The Brodhead (Wis.-Ill.) sheet, in Winnebago and Stephenson counties, was mapped by Mr. Van H. Manning, topographer, for publication on the scale of 1:62,500, with a contour interval of 20 feet. The Dunlap sheet, in Stark, Marshall, Peoria, Tazewell and Woodford counties, was mapped by Mr. D. C. Harrison on the same scale with a contour interval of 10 feet, as was also Hennepin sheet, in Bureau and Putnam counties. Lacon sheet, in Bureau, Putnam and Marshall counties, was also mapped by Mr. Harrison, on the above scale, with a contour interval of 20 feet, as was the Metamora sheet, in Marshall, Woodford, Peoria and Tazewell counties, with a contour interval of 10 feet.

1896.—The Cordova (Ia.-Ill.) sheet, in Carroll, Henry, Rock Island and Whiteside counties, was produced by Messrs. W. J. Peters and R. C. McKinney, topographers, on the scale of 1:125,000, with a contour interval of 20 feet. This map work was a revision of the Clinton, Goose Lake, Leclaire, and Henry sheets, scale 1:62,500, which it replaced.

1897.—Lancaster (Wis.-Ia.-Ill.) sheet, in Jo Daviess county, was mapped by Mr. C. E. Cooke, topographer, for publication on scale of 1:125,000, with a contour interval of 20 feet. Highwood sheet, in Cook and Lake counties, was mapped by Mr. R. C. McKinney, topographer, for publication on the scale of 1:62,500, with a contour interval of 10 feet. Evanston sheet, in Cook county, was also mapped by Mr. McKinney, on the same scale and with the same contour interval. Danville (Ill.-Ind.) sheet, in Vermilion county, was mapped by Mr. W. J. Lloyd, topographer, on the above scale and with the same contour interval.

1898.—O'Fallon sheet, in Calhoun and Jersey counties, was mapped by Mr. Paul Holman, topographer, for publication on the scale of 1:125,000, with a contour interval of 50 feet. The Rock Island (Ia.-Ill.) sheet, scale 1:125,000, contour interval 20 feet, was mapped in 1889, and revised for publication in 1898. It is formed by reduction of four 15-minute sheets, of which Davenport, Ia., sheet is one.

1900.—Kahoka (Mo.-Ia.-Ill.), in Hancock and Adams counties, publication scale 1:125,000, contour interval 20 feet, was mapped by Mr. Paul Holman, topographer. Mineral Point (Wis.-Ill.) sheet, scale 1:125,000, contour interval 20 feet, in Jo Daviess county, was mapped by Mr. R. C. McKinney, topographer.

1901.—New Harmony (Ind.-Ill) sheet, in White and Wabash counties, publication scale 1:62,500, contour interval 20 feet, was mapped by Mr. C. W. Goodlove, topographer. Princeton (Ind.-Ill.) sheet, in Wabash county, with above scale and contour interval, was also mapped by Mr. Goodlove. These sheets form by reduction, parts of the Patoka (Ind.-Ill.) thirty-minute sheet.

1902.—Mount Carmel (Ill.-Ind.) sheet, in Edwards, Wabash and White counties, scale 1:62,500, contour interval 20 feet, was mapped by Mr. C. W. Goodlove, topographer. It forms part of the Patoka (Ind.-Ill.) thirty-minute sheet, which latter was completed and published during the same year.

1903.—The St. Louis Special (Mo.-Ill.) sheet, was completed this year by Messrs. C. E. Cooke, W. O. Tufts, G. Young and the city of St. Louis, and was published on the scale of 1:24,000 with a contour interval of 20 feet. This sheet was reduced and included in the St. Louis double atlas sheet, scale 1:62,500 and contour interval 20 feet, a resurvey of the 1888 sheets.

1904.—Peoria sheet, in Tazewell, Peoria and Woodford counties, was mapped by Mr. C. E. Cooke, topographer, assisted by Mr. J. N. Williamson. This was on the publication scale of 1:62,500, with a contour interval of 10 feet.

The following list contains all topographic atlas sheets mapped by the United States Geological Survey outside of any coöperation with the State of Illinois. These sheets are arranged alphabetically by names. They show the exact area of any sheet within the State where the sheet overlaps one or more states. The total area mapped within the State is given.

The Geological Survey, in its measurement of areas, does not include large bodies of water bordering on political boundaries or the open ocean. The measurement closely follows the shore line, jumping from headland to headland across necks or straits less than 1,000 feet in width.

Quadrangles Mapped Prior to Co-Operation.

Quadrangle.	Area Mapped	Year.		Cont. Int.	Scale.
	Square miles.	Original Survey.	Resurvey or Revision.	Feet.	
Brodhead (Wis.-Ill.)	0.99	1891	....	20	1:62500
Calumet (Ill.-Ind.)	200.32	1889	1899	10	1:62500
Chicago	120.87	1889	1899	5	1:62500
Clinton (Ia.-Ill.)[2]	[1]*143.13*	1890	1896	20	1:62500
Cordova (Ia.-Ill.)[2]	492.81	1896	....	20	1:125000
Danville (Ill.-Ind.)	200.12	1897	....	10	1:62500
Davenport (Ia.-Ill.)[4]	[1]*7.46*	1889	....	20	1:62500
Des Plaines	223.36	1890	1899	10	1:62500
Dunlap	225.90	1891	....	10	1:62500
Evanston	28.55	1897	....	10	1:62500
Goose Lake (Ia.-Ill.)[2]	[1]*3.30*	1890	....	20	1:62500
Hennepin	224.21	1891	....	10	1:62500
Highwood	206.94	1897	....	10	1:62500
Joliet	223.36	1890	....	10	1:62500
Kahoka (Mo.-Ia.-Ill.)	3.11	1900	....	20	1:125000
Lacon	225.06	1891	....	20	1:62500
Lancaster (Wis.-Ia.-Ill.)	4.39	1898	....	20	1:62500
LaSalle	224.21	1891	....	10	1:62500
LeClaire (Ia.-Ill.)[2]	[1]*104.58*	1890	....	20	1:62500
Louisiana (Mo.-Ill.)	11.49	1888	....	50	1:125000
Marseilles	224.21	1890	....	10	1:62500
Metamora	225.90	1891	....	20	1:62500
Mineral Point (Wis.-Ill.)	10.46	1900	....	20	1:125000
Morris	224.21	1890	....	10	1:62500
Mount Carmel (Ill.-Ind.)[3]	180.45	1902	....	20	1:62500
New Harmony (Ind.-Ill.)[3]	44.78	1901	....	20	1:62500
O'Fallon (Mo.-Ill.)	71.74	1898	....	50	1:125000
Ottawa	224.21	1890	....	10	1:62500
Patoka (Ind.-Ill.)[3]	[1]*232.29*	1902	....	20	1:125000
Peoria	226.73	1904	....	10	1:125000
Peosta (Ia.-Ill.)	33.90	1890	....	20	1:125000
Princeton (Ind.-Ill.)[2]	7.06	1901	....	20	1:62500
Riverside	222.50	1890	1899	10	1:62500
Rock Island (Ia.-Ill.)[4]	7.26	1889	1898	20	1:125000
Savanna (Ia.-Ill.)	177.00	1890	....	20	1:62500
Ste. Genevieve (Mo.-Ill.)[5]	2.00	1895	....	50	1:125000
St. Louis (Mo.-Ill.). (double sheet)[5]	194.43	1888	1903	20	1:62500
St. Louis Special (Mo.-Ill.)[5]	....	1903	....	20	1:62500
Wilmington	224.21	1890	....	10	1:62500
Total	[1]4,916.83	....	....	....	....

[1] Figures in italic are not included in total, as the sheets form parts of other sheets whose total area are given.
[2] Clinton, Goose Lake, and LeClaire sheets, on scale of 1:62500 have been reduced, and form parts of Cordova sheet, on scale of 1:125000.
[3] Princeton, New Harmony, and Mount Carmel sheets, on scale of 1:62500, have been reduced, and form parts of Patoka sheet, on scale of 1:125000.
[4] Davenport sheet, on scale of 1:62500, has been reduced and forms part of Rock Island sheet, on scale of 1:125000.
[5] St. Louis Special sheet is included within the St. Louis double sheet.

DETAILED REPORT ON FIELD WORK.

Organization and Personnel.

During the field season of 1905 three parties were engaged under the supervision of Mr. C. E. Cooke, chief of section, in the topographic mapping of twelve atlas sheets, portions of three of which lie in the adjoining states of Indiana and Kentucky, the area in Kentucky having been mapped in coöperation with that state, while that in Indiana was mapped by the Federal Survey alone. The other two parties were in charge of Messrs. Albert Pike and W. J. Lloyd, topographers. Six quadrangles were completed during the season. Primary control was extended, under the supervision of Mr. S. S. Gannett, Geographer, by two parties under Messrs. E. L. McNair and J. R. Ellis, assistant topographers. One line of precise levels was run by Mr. McNair.

During the field season of 1906 Mr. W. H. Herron, topographer, was placed in supervisory charge of the section which includes Illinois, and under him three parties were maintained throughout the season under Messrs. W. J. Lloyd, topographer; C. L. Sadler, assistant topographer, and J. G. Staack, topographic aid. Towards the latter end of the season two parties under Messrs, A. T. Fowler, assistant topographer, and C. Hartmann, topographic aid, were added to these to aid in completion of work planned. During the season the topographic mapping of four atlas sheets was completed. Preliminary work was in progress on three others. Primary control was continued under the general supervision of Mr. S. S. Gannett, geographer. This work was done by a party in charge of Mr. L. E. Tucker, topographic aid. Two lines of precise levels were run by Mr. T. A. Green, field assistant.

During the field season of 1907 Mr. W. H. Herron, as Geographer in Charge of the Central Division of Topography, has supervisory control of all topographic surveys in Illinois, and under him Messrs. W. J. Lloyd and J. F. McBeth, topographers, Messrs. E. W. McCrary and H. L. McDonald, assistant topographers, and Lee Morrison and J. E. Tichenor, field assistants, were engaged in topographic mapping, three quadrangles being completed and five commenced. Primary control was continued by parties under the direction of Messrs J. R. Ellis and C. B. Kendall, assistant topographers. A line of precise levels was run by Mr. C. H. Semper, levelman, and primary and secondary levels were run by Messrs. W. A. Gelbach and Henry Bucher, levelmen.

During the season of 1908 Mr. Herron continued in charge of topographic work in Illinois. Topographic mapping was continued by Messrs. W. J. Lloyd and M. Hackett, topographers; E. W. McCrary and A. T. Fowler, assistant topographers; G. L. Gross, Lee Morrison and E. L. Hain, junior topographers, and J. W. Lovell and J. A. Duck, field assistants. Four quadrangles were completed and three were commenced. Primary levels were continued by Mr. W. A. Gelbach, junior topographer.

Summary of Results.

The following are tabular statements of the results of the field work of the seasons of 1905, 1906, 1907 and 1908:

SUMMARY STATEMENT OF FIELD WORK, 1905.

Counties.	Quadrangles.	Topographers.	Area mapped—Sq. miles.	Bench marks—Number.	Spirit levels—Miles.	Elevations—Number.	Secondary traverse—Miles.	Primary traverse—Miles.
Madison, St. Clair	Belleville	C. E. Cooke, L. S. Smith, W, J. Lloyd	233	12	727	3,776	910	
Gallatin, Saline, Hamilton, White	Eldorado	C. E. Cooke, W. J. Lloyd	236	12	578	4,247	894	
Champaign, Piatt	Mahomet	C. E. Cooke, A. Pike	228	12	582	4,094	576	
Gallatin, White	New Haven	C. E. Cooke, W. J. Lloyd, L. S. Smith	193	13	419	2,013	734	
Logan, Menard, Sangamon	Springfield	C. E. Cooke, A. Pike, F. T. Fitch.	229	11	578	5,185	1,082	
Champaign	Urbana	A. Pike	228	14	685	4,795	698	
Bond, Clinton, St. Clair, Madison.	Breese	W. J. Lloyd		10	58	206	578	
White	Carmi	..do			39	47		
Fulton, Mason	Havana	A. Pike		1	6	19		
Logan, Menard, Sangamon	Petersburg	A. Pike		3	14	39		
Cass, Schuyler, Fulton, Mason	Saidora	A. Pike		1	7	19		
DuPage	Wheaton	C. E. Cooke, A. Pike		12	47	6	751	
Champaign, Piatt, DeWitt, McLean, Tazewell		E. L. McNair		33[1]	87[1]	20[1]		
Champaign, DuPage, Clinton, Madison, Menard, St. Clair, Sangamon		J. R. Ellis						402
Total			1,347	134	3,827	24,466	6,223	402

[1] Precise levels.

SUMMARY STATEMENT OF FIELD WORK, 1906.

Counties.	Quadrangles.	Topographers.	Area mapped—Sq. miles.	Bench marks—Number.	Spirit levels—Miles.	Elevations—Number.	Secondary traverse—Miles.	Primary traverse—Miles.
Bond, Clinton, Madison, St. Clair.	Breese	C. L. Sadler	233	....	345	2,506	20	....
Franklin, Saline, Hamilton, Williamson	Galatia	C. L. Sadler, C. Hartmann	236	12	559	2,916	887	....
Lake	Waukegan	W. J. Lloyd, J. G. Staack	149	21	390	2,364	436	....
Cook, DuPage	Wheaton	W. J. Lloyd, J. G. Staack	226	....	596	3,513	....	....
Jo Daviess	Galena	W. J. Lloyd	....	....	30	167	104	....
Cass, Menard, Sangamon, Morgan.	Tallula	W. J. Lloyd	211	22	526	3,759	634	....
Franklin, Williamson	Thompsonville	C. L. Sadler	....	11	18	111	984	....
Franklin, Jackson, Perry, Williamson	Herrin	C. L. Sadler	....	....	....	....	162	....
Franklin, Jackson, Hamilton, Perry, Jo Daviess, Lake, Saline, Williamson	....	L. E. Tucker	....	....	....	....	....	398
Coles, Cumberland	....	T. A. Green	....	76[1]	206[1]	435[1]	....	....
Total	....	....	1,055	142	2,670	15,771	3,227	398

[1] Precise levels.

SUMMARY STATEMENT OF FIELD WORK, 1907.

Counties.	Quadrangles.	Topographers	Area mapped—Sq. miles.	Bench marks—No.	Spirit levels—Miles.	Elevations—No.	Secondary traverse—Miles.	Primary traverse—Miles.
Jackson, Perry, Williamson, Franklin	Herrin	W. J. Lloyd, G. L. Gross, J. S. Rohrer	131	15	620	5188	751	
Williamson, Franklin	West Frankfort	W. J. Lloyd, E. W. McCrary	236		854	6987	189	
Washington, Clinton, St. Clair	Okawville	E. W. McCrary, Lee Morrison, W. A. Gelbach, J. R. Ellis	69		164	1913	785	69
Crawford, Jasper, Lawrence, Richland	Hardinville	W. J. Lloyd, J. F. McBeth, H. L. McDonald, J. R. Lowell, J. E. Tichenor	93	28	775	5417	663	
Jackson, Perry	Murphysboro	W. J. Lloyd		18	66	375	748	
Washington, St. Clair, Monroe	New Athens	E. W. McCrary, W. A. Gelbach, J. R. Ellis		27	262	2203	909	43
Washington, Clinton, Bond	Carlyle	W. T. Lloyd, E. W. McCrary. R. C. O. Matheny, Lee Morrison, J. R. Ellis	77	20	372	3752	945	53
Richland, Jasper, Lawrence	Chauncey	J. R. Ellis						72
Sangamon, Menard	Tallula	W. J. Lloyd	18					
Edgar, Coles	Paris, Kansas	C. H. Semper		12[1]	32[1]			
Totals			624	120	3145	25835	4990	237

[1] Precise levels.

SUMMARY STATEMENT OF FIELD WORK, 1908.

Counties.	Quadrangles.	Topographers.	Area mapped—Sq. miles.	Bench marks—No.	Spirit levels—Miles.	Elevations—No.	Secondary traverse—Miles.	Primary traverse—Miles.
JoDaviess	Apple River	Henry Bucher		10	71	270	696	
JoDaviess	Galena	W. J. Lloyd		11	48	353	408	
Randolph	Baldwin	W. A. Gelbach, E. W. McCrary, J. R. Ellis	15	11	78	585	594	55
Lawrence, Wabash	Bridgeport	W. A. Gelbach, A. J. Johnson, A. J. Henley, Percy Kimmel, J. R. Ellis		19	412	2805		55
Clinton, Bond	Carlyle	A. T. Fowler, E. W. McCrary, A. J. Henley, A. O. Wood	156		102	470		
White, Posey	Carmi	W. J. Lloyd, W. A. Gelbach, J. R. Ellis		19	84	536	345	74
Crawford, Jasper, Lawrence, Richland	Hardinville	M. Hackett	139				37	
Putnam, Bureau, LaSalle	Hennepin	W. J. Lloyd, C. B. Kendall		18	67	516	556	62
Putnam, Bureau, LaSalle	LaSalle	W. J. Lloyd, C. B. Kendall		20	73	568	686	62
Williamson, Jackson, Perry, Franklin	Herrin	W. J. Lloyd, J. W. Lowell, J. A. Duck, G. L. Gross	105				50	
Jack on, Perry	Murphysboro	W. J. Lloyd, J. W. Lowell, G. L. Gross	236		576	5209	97	
St. Clair, Monroe	New Athens	W. J. Lloyd	35		462	2759		
St. Clair, Clinton, Washington	Okawville	W. J. Lloyd, E. W. McCrary, W. A. Gelbach	165	10	418	2468	25	
Fayette	Vandalia	E. W. McCrary	64				539	
Gallatin, Hardin	Shawneetown	J. R. Ellis						36
Total			915	118	2391	16539	4033	344

SPIRIT LEVELING.

Methods.

The elevations shown on the topographic maps are determined from accurate spirit leveling executed in three orders: First, precise leveling, whereby levels are brought hundreds of miles from mean sea level to different parts of the State, to furnish the fundamental bases to which further leveling is referred. This leveling is of the highest order. Some of it has already been executed by the Coast and Geodetic Survey, and recently this coöperative survey has run many lines of such leveling. Second, primary leveling is run in connection with the topographic mapping and consists of a high order of engineering levels, such as are run on railways or in cities. Lines of these levels are run with such frequency as to permit the placing of two permanent bench marks in each township. Third, based on the above, secondary leveling or flying leveling is run, with less accuracy, but yet within limits of about one foot, so as to procure elevations upon which to base the contour sketching, these lines of levels running practically into every section of one mile square within the area surveyed. In appendix attached hereto are printed instructions governing this work, as is a list giving elevations determined by leveling both prior to and since coöperation.

During 1905 and 1906 five parties were engaged in the running of spirit levels over the areas under survey, and in 1907 and 1908, seven parties were engaged in the same work. This leveling was done for the purpose of determining elevations and establishing bench marks upon which to base the contour sketching of the areas mapped. During the field season of 1905, 3,740 miles of spirit levels were run and 101 permanent bench marks were established; in 1906, 4,518 miles were run and 66 permanent bench marks were established; in 1907, 3,145 miles of levels were run and 161 permanent bench marks were established; in 1908, 2,391 miles of levels were run and 121 permanent bench marks were established. Appended hereto are descriptions of such bench marks as were established during the field seasons of 1905, 1906, 1907, and 1908, all of the precise leveling for 1906 and 1907, also of levels run prior to coöperation.

Detailed Results.

Introduction.—The following lists are based upon the precise level net as adjusted in 1907 by the Coast and Geodetic Survey upon a common mean sea level datum. The elevations are not, however, finally determined or accepted for all points given for the reason that the precise leveling of the Army Engineers along the Ohio River has not yet been published nor taken into account in fixing an elevation for Shawneetown. The net of precise level lines, which lie within or along the borders af this State, comprises also the line along the Mississippi River and the lines—Savanna, Ill., to Chicago, and Grafton, Ill., to Chicago; by the Army Engineers; the lines—Vincennes, Ind., to St. Louis, Mo., and

Cairo, Ill., to Odin, Ill., by the Coast Survey; and the line Pekin, Ill. via Fairmont Junction, Ill. to Olney, Ill., the spur, Fairmont Junction, Ill. to Catlin, Ill., and the lines Farrington, Ill. to Oakland, Ill., and Duquoin, Ill. to Shawneetown, Ill. of the United States Geological Survey.

All results of spirit leveling in this State previously published by the U. S. Geological Survey, and all later work are included in this report, rearranged by quadrangles.

The field work previous to 1903 was done under the general direction of Mr. J. H. Renshawe, geographer, that for 1903 to 1906, inclusive, under Mr. H. M. Wilson, geographer, and the later work under Mr. W. H. Herron. The work in the State was supervised in 1905, by Mr. C. E. Cook, topographer, chief of section, and in 1906 by Mr. W. H. Herron, then topographer and chief of section. The office work of computation adjustment and preparation of lists was done mainly by D. H. Baldwin, topographer, under the supervision of Mr. S. S. Gannett, geographer, and since 1907 under the general direction of Mr. E. M. Douglas, geographer.

The elevations are classified according to the accuracy of the method employed in their determination, precise and primary. The precise leveling done by the Geological Survey in this State consists of lines run in both forward and backward directions using high grade instruments, special precautions being taken in observations and reduction, and a small allowable limit of divergence adopted to insure the results to be continuously good throughout. The primary leveling consists of lines run with the ordinary "Wye" level, precautions being taken against principal sources of error. These lines are usually run in circuits of single lines required to close within a less severe limit of error. The allowable divergence adopted by the U. S. Geological Survey on precise lines is represented in feet by $0.017\sqrt{D}$, in which "D" represents the distance between bench marks in miles. The limit for primary work is represented in feet by $.05\sqrt{D}$, in which "D" represents the length of circuit in miles.

The standard bench marks are of the two following general forms:

First—A circular bronze or aluminum tablet 3.5 inches in diameter and 0.25 inch thick, appropriately lettered, having a 3-inch stem cemented into a drill hole, generally in the vertical walls of public buildings, bridge abutments or other substantial masonry structure.

Second—A form employed where masonry or rock is not accessible, consists of a hollow wrought iron post 3.5 inches in outer diameter and four feet in length after being split at bottom and expanded to ten inches in base so as to prevent both the easy subsidence of the post and its being maliciously pulled out of the ground. The iron is heavily coated with asphalt, and over the top of the post is riveted a bronze tablet similar to that described above.

The numbers stamped upon the bench marks as described in the following lists represent the elevations to the nearest foot above mean sea level, as determined by unadjusted levels in the field. They have been subjected to changes resulting from the adjustments necessary to close circuits and to those resulting from reduction to mean sea level through readjustment of the precise level net of the United States. In some

cases the finally accepted elevations as printed herein differ from those submitted as bench mark numbers by one or two feet. This method of numbering bench marks has been adopted where many levelmen are working in the same area at the same time as less liable to lead to confusion in identification of bench marks than any attempt at serial numbering, and because the bench mark number at the same time gives an approximate statement of the elevation. It is assumed that engineers and others finding these bench marks so stamped in the field will communicate with the Director of the U. S. Geological Survey in order to obtain the accepted elevation to hundredths or thousandths of a foot.

Any person finding bench marks in the following lists mutilated or destroyed will confer a favor by notifying the Director, United States Geological Survey, Washington, D. C.

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Precise Leveling.—Peoria, Mackinaw, Danvers, Leroy, Farmer City, Monticello, Mahomet, Urbana, Fithian and Danville Quadrangles—Champaign, DeWitt, McLean, Piatt, Tazewell and Vermilion Counties.

The following are the results of a line of precise levels run in 1905-1906; in 1905 from the U. S. Army Engineers' bench mark at Pekin over the C. C. C. & St. L. R. R. to Champaign, and continued in 1906 over the Wabash Railroad to Catlin. This line is connected at Fairmount Junction with a similar precise level line run from Olney, and together they form a link in the precise level net as adjusted in 1907. As a result of this adjustment the original elevations have been altered by amounts varying between plus .058 foot at Pekin and plus .051 foot at Fairmount Junction, and on the spur east to Catlin.

The methods, kind of instruments and limit of error used are those now adopted by the Coast and Geodetic Survey. On all sections upon which the forward and backward measures in millimeters differed more than $4.0\sqrt{K}$ (in which K is the distance between bench marks in kilometers), both forward and backward measures were repeated until a pair run in opposite directions came within limits, and all other requirements necessary to obtain accurate results were closely adhered to. In 1905 self reading rods were used 3.2 meters in length, graduated to centimeters and reading to millimeters by estimation. In the work of 1906 self reading rods of the same length were used but graduated to hundredths of a yard and reading by estimation to thousandths, computations being made in feet. The equivalent limit of error expressed in feet being $.017\sqrt{D}$ (where D is the distance in miles between bench marks.)

The leveling of 1905 was done by Mr. E. L. McNair and that of 1906 by Mr. T. A. Green, under the direction of Mr. S. S. Gannett.

The work was done in coöperation with the State and the standard bench marks are stamped with the State name and in addition with figures of elevation except on the portion run in 1905.

PEKIN, VIA CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS RAILWAY, TO CHAMPAIGN.

PEORIA QUADRANGLE.

	Feet.
Pekin, in water table on east side of county clerk's office; iron bolt (Pekin city bench mark)	479.092
Pekin, in water table on east side of county clerk's office; bronze tablet stamped" ? "	479.080
Pekin, in top of east abutment of Traction Line bridge across Illinois river, 12 feet north of center of track; copper bolt; "U. S. Army Engineers' bench mark," (P. B. M. 49)	455.422
Pekin, in front of Big Four station; top of rail	467.2
Leslie, 1 mile west of, 6 miles east of Pekin, 15 rails east of mile-post marked "P-15," 15 feet from center of Peoria and Eastern Railway track, in coping stone of concrete culvert; aluminum tablet stamped " ? "	681.979

MACKINAW QUADRANGLE.

	Feet.
Tremont, in front of station; top of rail........................	643.9
Tremont, 25 feet southeast of street crossing, at west end of concrete platform of station; iron post stamped " ? ".............	643.425
Menert, 0.33 miles west of, in top of north end of east abutment of plate girder bridge over Mud creek; aluminum tablet stamped " ? "	575.634
Menert, in front of station; top of rail........................	595.4
Minert, 0.67 miles east of, on top of and on south end of west abutment of a through bridge over Mackinaw river, 6 feet below top of rail, 3.5 feet from center of track, midway between south shoeplate and south floor beam in first panel from west; aluminum tablet stamped " ? "..	583.134
Mackinaw, 175 feet west of station, in top of first cap in east pier of first row of piers to railroad water tank; aluminum tablet stamped " ? "	646.239
Mackinaw, in front of station; top of rail........................	645.5
Lilly, in top of southwest corner of west end of concrete platform of railroad station, 5 feet north of center of track; aluminum tablet stamped " ? "..	803.268
Lilly, in front of station; top of rail........................	802.4

DANVERS QUADRANGLE.

Woodruff, 900 feet west of coaling sheds, 30 feet south of center of track, on right-of-way line in front of house of N. C. Osman; iron post stamped " ? "..	840.198
Danvers, about 120 feet south of station, in top of southwest corner west end of concrete platform of station; aluminum tablet stamped " ? "	809.268
Danvers, in front of station; top of rail........................	809.2
Danvers, 4.5 miles east of, 6 feet north of center of track, in coping of east wall of wagon pass under railroad; aluminum tablet stamped " ? "..	754.948
Twin Grove, in front of station; top of rail........................	817.3
Twin Grove, at north end of station platform, due south of elevator owned by F. Supple, 10 feet south of track; iron post stamped " ? "	816.420
Bloomington, 0.75 miles west of, at Chicago & Alton and Big Four junction, 15 feet from center of track, 6 feet below top of rail, in south side of west abutment of plate girder bridge across a creek used as an open sewer for city; aluminum tablet stamped " ? "..	746.283

LEROY QUADRANGLE.

Bloomington, Chicago & Alton junction, Kansas City division.....	775.3
Bloomington, in front of station; top of rail........................	789.3
Bloomington, about 350 feet east of passenger station, south of track, in north pier of water tank; aluminum tablet stamped " ? "	793.949
Bloomington, in southeast corner of court house, about 2 feet above ground and in face of wall, on a spur line from the preceding bench mark; aluminum tablet stamped " ? "	829.800
Bloomington, 1 mile east of; Illinois Central Railway crossing.....	857.7
Gillum, 2 miles west of, 20 feet from center of track, in top of parapet wall on south side of a concrete arch across a draw on the Big Four Railroad (arch is No. 300-88); aluminum tablet stamped " ? "	832.836
Gillum. 75 feet west of station, 20 feet from center of track, on south side and 1.75 foot below rail; iron post stamped " ? "......	820.416

	Feet.
Gillum, in front of station; top of rail	822.1
Downs, 360 feet east of station, 15 feet south of center of track, 10 feet northwest of section car house; iron post stamped " ? "	794.255
Downs, in front of station; top of rail	796.3
Ford Woods, 0.67 mile west of, 12 feet from center of track, in coping stone on north side of stone arch No. 293-94 on railroad; aluminum tablet stamped " ? "	791.339
Ford Woods, in front of station; top of rail	803.0
LeRoy, 300 feet east of station, 20 feet south of center of track, at intersection of right-of-way line and street line; iron post stamped " ? "	779.903
LeRoy, in front of station; top of rail	780.9

FARMER CITY QUADRANGLE.

Empire, 130 feet west of station. 15 feet north of center of track, 15 feet east of switch stand at siding; iron post stamped " ? "	755.580
Empire, in front of station; top of rail	756.7
Farmer City, 1 mile west of, 10 feet from center of track, in top on west side of abutment of a small I-beam bridge on railroad; aluminum tablet stamped " ? "	730.718
Farmer City, at Illinois Central crossing; top of rail	732.3
Farmer City, "Big Four Railway" bench mark (railroad elevation 723.500)	733.86
Farmer City, 375 feet east of junction of Big Four and Illinois Central railways, 18 feet south of center of track, 65 feet south of where first street east of Pittsburg and Eastern Railroad station crosses tracks; iron post stamped " ? "	732.510

MONTICELLO QUADRANGLE.

Harris, 60 feet west of station, 16 feet north of center of tracks; iron post stamped " ? "	721.633
Harris, in front of station; top of rail	722.8
Mansfield, 270 feet east of Wabash and Big Four railroad crossing, 18 feet south of center of Big Four track; iron post stamped " ? "	727.288
Mansfield station, at Wabash railroad crossing; top of rail	729.7

MAHOMET QUADRANGLE.

Mansfield, 3.5 miles east of, in south end of west abutment of plate girder bridge No. 270-40 on Big Four railroad; aluminum tablet stamped " ? "	721.663
Mahomet, 230 feet west of station, 15 feet north of center of track; iron post stamped " ? "	712.117
Mahomet, in front of station; top of rail	712.4
Mahomet, 2 miles west of, 10 feet from center of tracks, in top of south side of stone culvert No. 266-11 on Pittsburg and Eastern Railroad; aluminum tablet stamped " ? "	733.530
Rising, 75 feet west of station, 15 feet north of center of track; iron post stamped " ? "	734.092
Rising, in front of station; top of rail	735.7
Champaign, 2 miles west of, 15 feet south of center of track, in south side of west abutment of small I-beam bridge on Big Four Railway; aluminum tablet stamped " ? "	748.327

URBANA QUADRANGLE.

	Feet.
Champaign, 53 feet southeast of southeast corner of Engineering building of University of Illinois; iron post stamped "Prim. Trav. Sta. No. 1"	721.103
Champaign, on south side of east entrance to Engineering building of University of Illinois; aluminum tablet stamped " ? "	722.774

CHAMPAIGN, VIA WABASH RAILROAD SOUTHEAST, TO SIDNEY, THENCE EAST TO CATLIN.

URBANA QUADRANGLE.

Urbana, in front of station; top of rail	713.9
Urbana, 1059 feet east of station, 220 feet north of Wabash tracks, 45 feet south of Big Four tracks, in southwest corner of stone culvert under Big Four railroad; aluminum tablet stamped "?"	704.640
Mira, 2.03 miles northwest of, in east side of milepost "Cha 3-Tol 284;" spike	746.02
Mira, 1.03 miles northwest of, in east side of mile post "Cha 4-Tol 283;" spike	719.21
Mira, at road crossing; top of rail	695.8
Mira, 30 feet west of track, 30 feet south of road, 3 feet west of fence corner; iron post stamped "695 1906"	696.085
Deers, 1.29 miles northwest of, in west side of milepost "Cha 6-Tol 281;" spike	686.66
Deers, 0.99 miles northwest of, in west side of milepost "Cha 7-Tol 280;" spike	690.66
Deers, 65 feet west of track, 25 feet south of road, 70 feet north of store and post office of F. C. Edwards, at northeast corner of barn; iron post stamped "691 1906"	691.954
Sidney, in front of station; top of rail (Old elevation marked "669")	665.8
Sidney High School, in southwest corner of; aluminum tablet stamped "673 1906"	672.575
Sidney High School, at front entrance on south west corner of stone step, level with brick pavement; cross mark	670.73
Homer, 5.29 miles west of, on second tier of concrete on north side of abutment of Wabash Bridge over Chicago and Eastern Illinois Railroad; center of chiseled square	682.17
Homer, 3.56 miles west of, 45 feet north of milepost "St. L. 163-T-273," 35 feet north of track, 5 feet north of telegraph pole; iron post not stamped	668.028

FITHIAN QUADRANGLE.

Homer, 605 feet west of station, 30 feet north of track, 25 feet west of road, at east side of asphalt pavement; aluminum tablet stamped "674 1906"	674.484
Homer, in front of station; top of rail	676.4
Fairmount, 6.64 miles west of, 275 feet northeast of milepost "St. L. 168-T 268," in north side of telegraph pole; spike	670.70
Fairmount, 5.59 miles west of, 35 feet north of track, 25 feet east of road, near fence corner; iron post stamped "664 1906"	664.392
Fairmount, 4.59 miles west of, in east end of board at road crossing; top of spike	673.14
Fairmount, 3.69 miles west of, in north side of milepost "St. L. 171-Tol 265;" spike	675.91
Fairmount, 2.69 miles west of, 40 feet north of track, 50 feet north of mile post "St. L. 172-Tol 264;" iron post stamped "655 1906"	655.857

	Feet.
Fairmount, in front of station; top of rail	661.5
Fairmount, 1.71 miles west of, 240 feet northwest of milepost "St. L. 173-T. 263," on north side of lock; top of spike	656.840
Fairmount Junction, 56 feet northwest of, 50 feet west of Chicago and Eastern Illinois railroad tracks, 60 feet west of signal station, 35 feet north of Wabash tracks, in fence corner; iron post stamped "654 1906"	654.522
Fairmount Junction, Chicago and Eastern Illinois railroad and Wabash railroad crossing; top of rail	656.18

THE REMAINDER OF THIS LIST TO CATLIN IS RESULT OF A SPUR LINE.

Fairmount Junction, 1.01 miles east of; 120 feet west of road crossing, on south side of bridge; top of second bolt from west end	656.40
Fairmount Junction, 2.32 miles east of, in north side of milepost "St. L. 177-Tol 259;" spike	667.22
Fairmount Junction, 3.32 miles east of, 40 feet directly north of milepost "St. L. 178-Tol. 258," 30 feet north of track; iron post stamped "672 1906"	672.379
Fairmount Junction, 4.32 miles east of, in west side of milepost "St. L. 179-Tol. 257;" spike	674.01
Middle of bridge No. 7 over stream and wagon road; top of rail	664.89
Surface of water under bridge No. 7; October 29, 1906	648.

DANVILLE QUADRANGLE.

Fairmount Junction, 5.09 miles east of, on south side of bridge No. 6; top of fifth bolt from west end	665.69
Catlin, in front of station; top of rail	663.8
Catlin station, section 34, T. 19 N., R. 12 W., 195 feet north of track, 30 feet west of road, at "Champion's Corner;" iron post stamped "658 1906"	657.396

Olney, Newton, Greenup, Bradbury, Mattoon, Oakland, Kansas, Sidell, and Fithian Quadrangles—Coles, Cumberland, Douglas, Jasper and Richland Counties.—The following elevations are the result of a precise level line run from a bench mark of the trans-continental levels at Olney north to Fairmount Junction where it connects with a similar line from Pekin. The two together formed a link in the precise level net and being of a class receiving the highest weight, there has only been a small adjuustment of 0.006 foot and 0.007 foot, respectively, distributed in these lines whereas the new elevation, accepted for Olney, is 0.785 greater than that determined by the adjustment of 1903. The usual method of direct and reverse leveling was employed, the line being broken by temporary bench marks into sections of about a mile, and the partial discrepancies in feet required to not exceed 0.017 times the square root of the distance between bench marks in miles. All the usual precautions were taken and corrections made.

The leveling was done in 1906 by T. A. Green, under the direction of S. S. Gannett.

The work was done in coöperation with the State and the standard bench marks are stamped with the State name.

Olney North Along Illinois Central Railroad, to Lerna.

OLNEY QUADRANGLE.

	Feet.
Olney, cut at the base of one of the columns at the north face of Richland County courthouse; marked "B_3-U. S. C. & G. S.-B. M.-1882"	486.117
Olney, Richland County Courthouse, in top west stone balustrade of steps at south entrance; aluminum tablet stamped "483 1906"	483.645
Olney, in front of station; top of rail	472.8
Olney, 0.86 miles north of, 30 feet west of track, 90 feet south of lock to switch at C., H. & D. junction; top of rail driven in ground	461.661

NEWTON QUADRANGLE.

Olney, 2.87 miles north of, 45 feet west of road crossing, 40 feet north of road, in southeast corner of lot owned by J. M. Fleming; iron post stamped "465 1906"	465.529
Olney, 5.36 miles north of, 30 feet east of track, 40 feet southeast of private road crossing, 50 feet southeast of whistle post, 10 feet south of gate to house; iron post stamped "475 1906"	475.308
Dundas, in front of station; top of rail	478.4
Dundas, 439 feet north of station, 50 feet northeast of road crossing, 30 feet east of track, in southwest corner of Dundas Rolling Mill; aluminum tablet stamped "480 1906"	481.292
West Liberty, in front of station; top of west rail	484.0
West Liberty, 1.59 miles north of, 160 feet north of milepost "169-78;" 70 feet south of bridge "B-163-93," 590 feet south of road crossing, 30 feet east of tracks, east of right of way line; iron post stamped "480 1906"	481.253
West Liberty, 4.52 miles north of, 8 feet west of milepost "166-81;" iron post stamped "506 1906"	507.128
Boos, in front of station; top of rail	517.4
Boos, 1.84 miles north of, 40 feet northeast of milepost "163-84," 25 feet east of track, 15 feet east of warning post, 50 feet southeast of road crossing, in fence corner; iron post stamped "524 1906"	525.217
Newton, 180 feet northwest of station, 70 feet west of railroad crossing, 20 feet west of water plug on south side of road; iron post stamped "512 1906"	512.989

GREENUP QUADRANGLE.

Newton, 3.03 miles north of, 165 feet south of milepost "157-90," 30 feet east of track, 10 feet north of private road crossing, in fence corner; iron post stamped "538 1906"	538.806
Falomuth, 1.4 miles north of, 40 feet east of track, at edge of fence, 50 feet east of milepost "154-93," 175 feet west of oil derrick; iron post stamped "564 1906"	564.880
Rose Hill, in front of station; top of rail	567.4
Rose Hill, 1.05 mile north of, 553 feet north of milepost "151-96," 35 feet southeast of road crossing, in fence corner; iron post stamped "566 1906"	566.634
Hidalgo, in front of station; top of rail	583.1
Hidalgo, 0.31 mile north of, 30 feet west of track, 8 feet west of milepost "148-99;" iron post stamped "581 1906"	582.276
Hidalgo, 3.37 miles north of, 245 feet north of milepost "145-102," 30 feet east of track, 9 feet north of center of road through field, at edge of right of way; iron post stamped "593 1906"	593.640
Greenup, at junction of Illinois Central and Vandalia line; top of rail	553.9

	Feet.
Greenup, in front of Illinois Central Railroad station; top of rail ...	553.9
Greenup, 700 feet northwest of station, 40 feet north of track, 570 feet southeast of milepost "142-105;" iron post stamped "543 1906"	543.690

BRADBURY QUADRANGLE.

Greenup, 3.18 miles northwest of, 45 feet northwest of road crossing, 25 feet north of warning post, 15 feet west of wagon road; iron post stamped "553 1906"	553.387
Toledo, in front of station; top of rail	601.1
Toledo, 0.75 mile north of, 210 feet north of milepost "136-111," 35 feet west of track, 10 feet north of private road to Glenn Mowel house, in fence corner; iron post stamped "602 1906"	602.864
Bradbury, 630 feet north of station, 25 feet west of track, 3 feet west of milepost "133-114;" iron post stamped "607 1906"	608.131
Janesville, 0.53 mile south of, 30 feet west of track, in fence corner 20 feet south of road; iron post stamped "676 1906"	676.582
Janesville, 2.6 miles northwest of, 235 feet south of milepost "127-120;" 35 feet east of track, in fence corner; iron post stamped "735 1906"	735.938

MATTOON QUADRANGLE.

Lerna Junction, Illinois Central and Toledo, St. Louis and Western Railroads; top of rail	754.3
Lerna, southeast corner of station, on east side at corner of platform 113 feet northwest of junction; iron post stamped "753 1906" ...	754.316

LERNA NORTHEAST BY TOLEDO, ST. LOUIS AND WESTERN RAILROAD, TO BROCTON.

MATTOON QUADRANGLE.

Lerna, 2 miles northeast of, 60 feet east of milepost "St. L. 125-T 326," 10 feet south of rail rack, in south end of terra cotta drain pipe; chiseled hole	721.39
Lerna, 3.01 miles northeast of, 40 feet north of track, 20 feet east of road; iron post stamped "708 1906"	708.589
Lerna, 3.99 miles northeast of, 250 feet northeast of milepost "St. L. 127-T 324," 20 feet north of whistle post, in top of rock; chiseled hole	677.89
Lerna, 5.74 miles northwest of, 50 feet north of track, 25 feet east of road, 20 feet west of silver poplar tree; iron post stamped "615 1906"	615.548
Charleston, on southwest corner of "Clover Leaf" station, 5 feet east of entrance to baggage room, in stone coping; aluminum tablet stamped "672 1906"	672.804
Charleston, Coles County Courthouse, 15 feet west of north entrance, in section of building occupied by U. S. Post Office, in west end of top step; aluminum tablet stamped "686 1906"	686.536
Charleston, in front of station (Clover Leaf Railroad); top of rail	678.5

OAKLAND QUADRANGLE.

Charleston, 3.68 miles north of, 35 feet east of track, 25 feet north of county road, in southwest corner of G. W. Wasson's lot; iron post stamped "686 1906"	686.866
Fairgrange, in front of station; top of rail	683.1

	Feet.
Fairgrange, 0.95 mile northeast of, 45 feet south of rock, 25 feet south of warning post, 25 feet east of county road, 2 feet west of fence corner; iron post stamped "686 1906"	687.083
Bushton, in front of station; top of rail	672.6
Bushton, 0.85 mile northeast of, 50 feet northeast of road crossing, 30 feet north of county road, near fence corner; iron post stamped "666 1906"	666.586
Rardin, in front of station; top of rail	664.9
Rardin, 1.58 miles northeast of, 53 feet south of private road crossing, 10 feet south of angle in road; iron post stamped "658 1906".	658.348
Oakland, 820 feet south of junction, 60 feet west of track, 140 feet northwest of milepost "St. L. 147-T. 304," 25 feet south of wagon road; iron post stamped "652 1906"	653.022
Oakland, at Clover Leaf Junction with Vandalia railroad; top of rail	656.6

KANSAS QUADRANGLE.

Oakland, 2.98 miles north of, 50 feet east of track, 30 feet east of milepost "St. L. 150--T. 301," 465 feet north of small bridge No. 302, in edge of field; iron post stamped "661 1906"	661.593
Brocton, 0.47 mile southwest of, 65 feet north of road crossing, 35 feet west of track, in fence corner; iron post stamped "661 1906".	662.182
Brocton, at junction of Clover Leaf and Cincinnati, Hamilton and Dayton railroads; top of rail	662.7

BROCTON NORTH, VIA CINCINNATI, HAMILTON AND DAYTON RAILROAD, TO SIDELL.

KANSAS QUADRANGLE.

NONE.

SIDELL QUADRANGLE.

Brocton, 2.36 miles northeast of, at Payne's Siding, 25 feet east of tracks, 50 feet southeast of switch, 6 feet east of telephone pole, 15 feet north of county road; iron post stamped "678 1906"	678.662
Hughes, 0.48 mile northeast of, 40 feet east of track, 12 feet east of telegraph pole; iron post stamped "655 1906"	656.265
Hume, 1.47 miles north of, 1,000 feet north of milepost "Olney 78-Sidell 7," 40 feet east of track, 90 feet northeast of whistle post; iron post stamped "645 1906"	646.299
Hume, 4.34 miles north of, 330 feet north of milepost "Olney 81-Sidell 4," 25 feet west of track, 5 feet north of private road; iron post stamped "693 1906"	693.572
Hildreth, in front of station; top of rail	714.3
Hildreth, 1.99 miles north of, at road crossing, 150 feet north of Archie Siding, 30 feet west of track, 10 feet south of road; iron post stamped "691 1906"	691.984
Sidell, in west side at northwest corner in water shed of high school, 2 feet south of corner of building; aluminum tablet stamped "684 1906"	685.184
Sidell, in front of station; top of rail	681.9

SIDELL NORTH BY ROSSVILLE BRANCH C. & R. R. R., TO FAIRMOUNT JUNCTION.

SIDELL QUADRANGLE.	Feet.
Sidell, 3.13 miles northeast of, 50 feet east of track, 10 feet north of private road; iron post stamped "679 1906"	679.859
Jamaica, in front of station; top of rail	683.3
Jamaica, 145 feet northwest of station, 100 feet west of track, 30 feet north of road, at southeast corner of Joe Collin's store (owned by Wm. Gohain); iron post stamped "677 1906"	677.913

FITHIAN QUADRANGLE.	
Jamaica, 2.22 miles north of, 60 feet west of track, 70 feet northwest of milepost "C 134-T. 260," 195 feet northwest of switch; iron post stamped "668 1906"	668.351
Fairmount Junction, at junction of Chicago and Eastern Illinois and Wabash railroads; top of rail	656.2
Fairmount Junction, 56 feet northwest of, 50 feet west of Chicago and Eastern Illinois tracks, 60 feet west of signal tower, 35 feet north of Wabash tracks, in fence corner; iron post stamped "654 1906"	654.522

Kansas, Marshall, Oakland and Paris quadrangles—Clark, Coles and Edgar Counties.—The elevations in the following list are the unadjusted results of a line of precise levels run from Farrington to Oakland and based upon the 1907 adjustment value at Oakland. They are the Illinois portion of a line run from Mitchell, Indiana, to Oakland, Illinois. At Oakland the connection is made with a similar precise line of the Geological Survey adjusted between Olney and Pekin junction points of the precise level net. The values computed from Mitchell, Indiana would be 0.6 foot greater those those here given, but since this line was not involved in the 1907 adjustment and since it has much greater weight than the Coast and Geodetic Survey line through Mitchell, it was thought best not to distribute any part of this adjustment in this Illinois portion of the line and to determine later a new elevation for Mitchell, Indiana. A prism level, yard rods, and the standard method were used. The divergence between the forward and backward lines for entire distance from Mitchell was 0.215 foot in 132.8 miles and for the Illinois portion alone 0.013 foot in 31.5 miles.

The leveling was done in 1907 by C. H. Semper.

The leveling was done in coöperation with the State and the standard bench marks are stamped with the State name.

FROM THE STATE LINE NEAR FARRINGTON STATION NORTHWEST ALONG VANDALIA RAILROAD, TO OAKLAND.

MARSHALL QUADRANGLE.	Feet.
Farrington, in front of station; top of rail	570.7
Farrington, 1.83 miles west of, 0.24 mile southwest of milepost "T. H. 10," east of track, in top of railroad culvert; aluminum tablet stamped "580"	579.453
Ferrell, in front of station; top of rail	604.7
Marley, in northeast corner of front wall of Methodist Episcopal Church; aluminum tablet stamped "644"	644.155

	Feet.
Marley, in front of station; top of rail	645.8
Marley, 2.1 miles northwest of, 750 feet southeast of milepost "T. H. 15," west of track, in top of railroad culvert; aluminum tablet stamped "673"	673.149

PARIS QUADRANGLE.

Marley, 4.31 miles northwest of, 100 feet east of road, in southwest corner of front wall of McCall school house, 300 feet east of track; aluminum tablet stamped "728"	728.065
Paris, in front of station; top of rail	735.7
Paris, at east end of Vandalia freight station, in wall; aluminum tablet stamped "739"	739.225

KANSAS QUADRANGLE.

Mays, 150 feet southeast of milepost "T. H. 26," north of track, in top of railroad culvert; aluminum tablet stamped "691"	690.424
Mays, in front of station; top of rail	689.6
Mays, 1.29 miles west of, 1050 feet west of road crossing, in top of south end of railroad culvert; aluminum tablet stamped "681"	680.538
Redmon, in front of station; top of rail	683.0
Redmon, in front wall of Redmon Bank; aluminum tablet stamped "691"	690.300
Borton, 0.51 mile east of, in top of railroad culvert north of track at road crossing; aluminum tablet stamped "664"	664.209
Borton, in front of station at crossing of C. H. & D. R. R.; top of rail	664.9
Isabel, in front of station; top of rail	669.2
Isabel, 2.02 miles west of, 276 feet west of road crossing, 100 feet north of track, in house of Ed. Gobert's; aluminum tablet stamped "645"	644.680

OAKLAND QUADRANGLE.

Oakland, 250 feet west of crossing of T. St. L. & W. R. R., in front wall of J. T. Simms' grain elevator; aluminum tablet stamped "659"	658.718
Oakland, at crossing of Vandalia Railroad and T. St. L. & W. R. R.; top of rail	656.6
Oakland, 820 feet south of junction, 60 feet west of track, 140 feet northwest of M. P. St. L. 147, 25 feet south of highway; iron post stamped "652"	653.022

Duquoin, Eldorado, Equality, Herrin, Shawneetown and West Frankfort Quadrangles—Franklin, Galatia, Perry and Saline Counties.—The following are the unadjusted results of a line of precise levels run from Duquoin southeastward along the Illinois Central R. R. to Shawneetown. The elevations are based upon the bench mark "R3" at Duquoin on the Coast and Geodetic Survey precise level line, Cairo to Odin, Illinois. It is the bottom of a square cut in corner of stone sill at main door opposite Illinois Central Railroad station and its accepted elevation is 462.477 as obtained by the adjustment of 1907 made by the Coast and Geodetic Survey.

The method, type of instrument, and limit of error are the same as those now used by the Coast and Geodetic Survey. The self-reading rods used were 3.5 yards in length, graduated to yards and hundredths

and read by estimation to thousandths, which enabled computation to be made directly in feet instead of meters as is done by the Coast Survey. On all sections upon which the forward and backward measures in feet differed more than $0.017\sqrt{D}$ (in which D is the distance between bench marks in miles) both forward and backward measures were repeated until a pair run in opposite directions came within limits, and all other requirements necessary to obtain accurate results were closely adhered to.

The leveling was done in 1906 by T. A. Green under the direction of S. S. Gannett.

The standard bench marks are stamped with figures of elevation and year. Many are stamped with a value one foot too small but will probably be restamped when further work is done in the locality.

Duquoin, Southeasterly Along Illinois Central Railroad, to Shawneetown.

DUQUOIN QUADRANGLE.	Feet.
Duquoin, Coast and Geodetic Survey bench mark "R_3," at bottom of a square cut in corner of stone sill at main door opposite Illinois Central Railroad station; the cavity is marked thus "[]".........	462.477
Duquoin, 600 feet east of station, in east brick wall of Exchange Bank; aluminum tablet stamped "468 1906"......................	468.427
Duquoin, in front of station; top of rail............................	463.7
Duquoin, 3.2 miles east of, 60 feet west of creek, 40 feet north of railroad just south of fence corner; iron post stamped "396 1906".	396.407
HERRIN QUADRANGLE.	
McDonald, in front of station; top of north rail..................	395.9
McDonald, 1 mile southeast of, 60 feet directly north of milepost "East St. Louis 77 mi., Eldorado 44 mi."; iron post stamped "402 1906"	401.898
Mulkeytown, in front of station; top of rail	424.4
Mulkeytown, 324 feet south of station, in east side of cornerstone at hall of "Modern Woodmen of America;" aluminum tablet stamped "449 1906"	449.025
Christopher, in front of station; top of rail......................	438.9
Christopher, in southwest corner of Christopher National Bank; aluminum tablet stamped "443 1906".................................	443.866
Buckner, in front of station; top of rail..........................	408.5
Christopher, 2.8 miles east of, 348 feet west of small railroad bridge over stream, 150 feet southeast of house occupied by Isaac Denton; iron post stamped "392 1906"............................	392.968
WEST FRANKFORT QUADRANGLE.	
Christopher, 5.7 miles east of, 150 feet southeast of road crossing, at northwest corner of house occupied by W. M. Wolf; iron post stamped "438 1906"	439.161
Benton, Franklin county court house, 1507 feet north of station, in stone step just south of west entrance; aluminum tablet stamped "474 1906"	475.832
Benton, in front of station; top of rail...........................	470.7
Benton, 0.3 mile east of, at junction of Chicago & Eastern Illinois and Illinois Central railroads; top of rail......................	471.1
Benton, 2.3 miles southeast of, 90 feet directly north of milepost "E. St. Louis 92-Eldorado 29;" iron post stamped "405 1906"........	406.605

	Feet.
Smothers (Smotherville P. O.), in front of station; top of rail......	481.5
Smothersville post-office, 260 feet southeast of road crossing, at northwest corner of store kept by M. M. Moore; iron post stamped "479 1906"	479.994
Parrish, 200 feet northeast of road crossing, at southwest corner of store kept by Brown & Moore; iron post stamped "438 1906"......	439.500
Parrish, in front of station; top of rail..........	438.1
Thompsonville, 600 feet south of road crossing, 100 feet east of brick school house; iron post stamped "Prim. Trav. Sta. No. 4—494 1906"	495.401
Thompsonville, in front of station; top of rail..........	499.9

GALATIA QUADRANGLE.

West End, 75 feet north of station, in south wall of "West End Rolling Mill;" aluminum tablet stamped "429 1906"..........	430.507
West End, 60 feet east of station; top of rail	425.9
Rileyville, in front of station; top of rail	398.9
Rileyville, 0.71 mile southeast of, 20 feet northwest of cattleguard, in corner of fence at point where county road jogs north from railroad; iron post stamped "392 1906"	393.222
Galatia, 0.3 mile west of station, at "Galatia Rolling Mill," in southwest foundation of old elevator; aluminum tablet stamped "397 1906." (This bench mark is to be destroyed)..........	398.186
Galatia, in front of station; top of rail..........	401.5
Galatia, 3.18 miles southeast of, 20 feet directly south of milepost "E. St. Louis 114-Eldorado 7," inside of fence; iron post stamped ' ? "	394.403
Raleigh, in front of station; top of rail..........	407.2
Raleigh, 1.59 miles east of, 70 feet west of milepost "E. St. Louis 117 mi-.Eldorado 4 mi.," 62 feet south of center of tracks; iron post stamped "390 1906"	391.099

ELDORADO QUADRANGLE.

Eldorado, 30 feet south of southwest corner of Grand Hotel at edge of pavement; iron post stamped "388 1906"..........	387.904
Eldorado, just east of station, at junction of Big Four and Louisville & Nashville railroad; top of rail	391.9
Grayson, 30 feet west of station; top of rail..........	407.1
Grayson, 0.49 mile southeast of, 40 feet north of center of track; inside of wire fence; iron post stamped "1906"..........	392.649

EQUALITY QUADRANGLE.

Grayson, 3.1 miles southeast of, 40 feet northwest of road crossing, on west side of road; iron post stamped "1906"..........	363.044
Equality, at northwest corner of Louisville & Nashville railroad station; iron post stamped "1906"..........	362.272
Equality, in front of station; top of north rail..........	362.9
Equality, 2.7 miles southeast of, 100 feet southeast of E. P. Fowler's residence, 40 feet north of track in fence corner; iron post stamped "1906"	376.921
Equality, 5.7 miles southeast of, 60 feet north of milepost "St. Louis 138-Shawneetown 6 mi.;" iron post stamped "1906"..........	353.142

SHAWNEETOWN QUADRANGLE.

Cypress Junction, at crossing of Louisville & Nashville and Baltimore & Ohio railroads; top of rail..........	355.9
Cypress Junction, 30 feet east of station; top of rail..........	358.0

	Feet.
Cypress Junction, 2.5 miles east of, 330 feet west of road crossing, 50 feet north of milepost "St. Louis 141-Shawneetown 5 mi.;" iron post stamped "1906"	396.512
Shawneetown, in front of station; top of rail	350.2
Shawneetown, at southwest corner of Louisville & Nashville railroad station; iron post stamped "1906"	349.598
Shawneetown, 100 feet east of southeast corner of "Riverside Hotel" in northeast corner of concrete gun rack; aluminum tablet stamped "1906"	365.968

Primary Leveling—Galena and Apple River Quadrangles—JoDaviess County.

The following elevations are based upon the precise level line of the Mississippi River Commission along the Mississippi river and upon the 1907 adjustment.

The leveling was done in 1908 by Henry Bucher.

The work was done in coöperation with the State and the bench marks are stamped with the State name.

Galena Quadrangle.

PLEASANT HILL SCHOOL WEST, TO BLANDING, THENCE NORTH, VIA GALENA JUNCTION AND GALENA, TO SEC. 24, T. 29 N., R. 1 W., THENCE EAST, TO SCALES MOUND.

	Feet.
T. 26 N., R. 2 E., northeast quarter of section 11, at T road, at Pleasant Hill school house, west of road, 120 feet north of fence corner, 4 feet east of fence; iron post stamped "Prim. Trav. Sta. No. 19, 965"	964.637
T. 26 N., R. 2 E., near center of section 11, at angle in road, south of road, in root on west side of 30-inch oak tree, nail; marked "945"	946.05
Hanover, at southwest corner of Hanover Hotel; iron post stamped "Prim. Trav. Sta. No. 28, 632"	632.215
Hanover, south side of, in southwest quarter of section 9, T. 26 N., R. 2 E., at southwest corner of Y road, south of road, in root on northeast side of 12-inch hard maple tree; nail	635.93
T. 26 N., R. 2 E., north of center of section 17, at Y road, on northeast side of road, in root on south side of 48-inch oak tree; nail	900.64
T. 26 N., R. 1 E., in southwest quarter of section 12, at northeast corner of road crossing, in field corner, 3.7 feet north of fence north of wagon road, 5 feet northeast of railroad right-of-way fence; iron post stamped "626"	626.292
Bellevue, Iowa, opposite, 0.5 mile from river, 0.5 meter from fence in wagon road leading back from ferry landing, 100 meters beyond 100-foot wooden bridge across slough, to birch 102 degrees—16.7 meters; tile and pipe; "Mississippi River Commission Bench Mark 173." (Bridge and fence no longer remain and no stump of 10-inch birch; iron pipe has been disturbed and at time visited was half filled with water.)	
Cap on pipe	594.38
Bolt in tile	590.44
Blanding, at east corner of road, oposite general store, 1.7 feet southwest of fence; iron post stamped "Prim. Trav. Sta. No. 27, 631"	631.354
T. 27 N., R. 1 E., 0.13 mile east of center of section 16, public road crossing, south of road on bank, 40 feet west of railroad, 8 feet west of line of railroad right-of-way fence; iron post stamped "614"	614.008

	Feet.
Galena Junction, in southeast corner of cap on south pier of Chicago, Burlington and Nashville Railroad drawbridge across Galena river; aluminum tablet stamped "606"	606.212
Galena Junction, on northeast corner of south pier of Illinois Central Railroad drawbridge over Galena river, one foot from north side, 6 inches from east end, on cap, cross in center of black painted spot with ring of white around it (Mississippi River Commission temporary bench mark 15-L. B.)	606.240
Galena, at northeast corner of Chicago, Burlington and Quincy Railroad station grounds, 36.3 feet northeast of northeast corner of building, 3.6 feet from telephone pole, 7.1 feet southwest of southwest corner of public bridge over Galena river; iron post stamped "603"	603.191
T. 28 N., R. 1 W., east of quarter corner between sections 2 and 11, east of road in school grounds, in root on southwest side of large soft maple tree second in row from northwest end; nail	840.39
T. 28 N., R. 1 W., near north quarter corner of section 2, at northwest corner of Y road, in field, 14 feet north of east and west fence, 1.7 feet west of north and south fence; iron post stamped "867"	866.763
T. 29 N., R. 1 W., near center of section 24, at northeast corner of crossroads, in field, 3.5 feet north of east and west fence, 3 feet east of north and south fence; iron post stamped "929"	928.699

(*Line turns east.*)

Day's Siding, west of center of section 22, T. N., R. 1 E., road crossing Chicago and Northwestern Railroad, 15 yards north of railroad at intersection, 1.5 feet south of old board and wire fence, near an old braced telephone pole; iron post stamped "670"	669.313
T. 29 N., R. 1 E., near center of section 27, at northeast corner of Y road, 1.6 feet south of east and west fence, 8 feet east of fence corner; iron post stamped "Prim. Trav. Sta. No. 23, 864"	863.510
Council Hill, section 25, T. 29 N., R. 1 E., in masonry foundation to Methodist Episcopal Church, 1.7 feet from north corner in northwest face of northeast wing; aluminum tablet stamped "926"	925.374
T. 29 N., R. 2 E., in southwest quarter of section 30, at northeast corner of T road, in root on northwest side of 24-inch oak tree; nail	851.37

(*Turn east on Illinois Central Railroad from Council Hill station.*)

T. 29 N., R. 2 E., in southwest quarter of section 21, 2.57 miles east of Council Hill station, 290 feet west of wagon road which passes under stone culvert "W-155-56" in right of way, 2 feet south of fence; iron post stamped "835"	834.690
Scales Mound, 22 paces north of Illinois Central Railroad, 25 paces southwest of James Allen's general store, in center of small triangle; iron post stamped "948"	948.006

MORLEY SCHOOL WEST, TO GALENA.

T. 28 N., R. 2 E., in southeast quarter of section 26, at southwest corner of T road, 25 feet east of fence corner, on opposite side of road from Mount Morley schoolhouse; iron post stamped "Prim. Trav. Sta. No. 18, 1043"	1,042.721
T. 28 N., R. 2 E., near center of section 29, 570 feet east of Y road, north of road in field, 2 feet north of fence; iron post stamped "1067"	1,066.176
T. 28 N., R. 1 E., near corner of sections 22, 23, 26 and 27, at northeast corner of Y road, in southwest corner of Mt. Hope schoolhouse grounds, 4 feet from edge of bank, 8.5 feet southwest of 36-inch hard maple tree; iron post stamped "834"	833.732

Feet.

Galena, at northeast corner of intersection of Bogges and Bouthillier streets, in root on west side of 36-inch soft maple tree; nail 785.20

SCALES MOUND SOUTH TWO MILES.

Scales Mound, at southwest corner of schoolhouse grounds, 2.8 feet north of wooden sidewalk running east and west on north side of schoolhouse; iron post stamped "Prim. Trav. Sta. No. 17, 956".. 955.640

T. 28 N., R. 2 E., near center of section 2, at cheese factory at Y road, 400 feet east of Y, in top of south side of west abutment wall to iron bridge; aluminum tablet stamped "833" 832.926

Apple River Quadrangle.

SCALES MOUND EAST, VIA APPLE RIVER, TO NEAR WARREN, THENCE SOUTH, VIA STOCKTON, TO TOWNSHIP LINE, THENCE WEST, TO PLEASANT HILL SCHOOL.

Sawsiding, 0.6 mile west of, southeast corner of southwest quarter of section 20, T. 29 N., R. 3 E., in corner of field, 20 paces south of south rail of Illinois Central Railroad, 3 paces east of wagon road which crosses track; iron post stamped "987" 986.293

T. 29 N., R. 3 E., near northeast corner of section 22, 2.5 miles west of Apple River, at southwest corner of north and south road crossing Illinois Central Railroad, in field, 5.7 feet west of fence, 14 feet south of fence; iron post stamped "1007" 1,006.885

Apple River, in southwest corner of yard of W. H. Smith; iron post stamped "Prim. Trav. Sta. No. 16, 994" 994.043

Apple River, at northeast corner of Railroad and Main streets, in face of concrete walk in front of Anschutz Brother's general store, 2.4 feet east of north and south crossing walk, 0.9 foot below pavement level; aluminum tablet stamped "996" 995.536

T. 29 N., R. 4 E., near south quarter corner of section 14, about 1.25 miles northwest of Warren, at southwest corner of road crossing west of road; iron post stamped "994" 993.187

T. 29 N., R. 4 E., north quarter corner of section 26, 0.25 mile south of T road, at southwest corner of schoolhouse grounds, west of road south of corner, in root on east side of 15-inch hard maple tree first in row, nail; marked "G. S. B. M. 993.2" 992.86

T. 29 N., R. 4 E., about 0.13 mile west of east quarter corner of section 35, at southwest corner of T road, in field, 1.5 feet south of fence, 2 feet west of fence; iron post stamped "993" 992.997

T. 28 N., R. 4 E., in southeast quarter of section 14, at Y road, in field at northwest corner of Y, at Robinson schoolhouse, 11 feet north of fence, 8 feet west of fence; iron post stamped "868" .. 867.421

T. 28 N., R. 4 E., near quarter corner between sections 35 and 36, at northeast corner of crossroads in field, 5 feet east of north and south fence, 3 feet north of east and west fence; iron post stamped "973" 972.921

T. 27 N., R. 4 E., corner of sections 11, 12, 13 and 14, at southeast corner of T road, in field, 2.7 feet south from east and west fence, 3.4 feet east of north and south fence; iron post stamped "1018"..1,017.724

T. 27 N., R. 4 E., quarter corner between sections 23 and 26, south of road at crossroads, about 40 feet east of corner and 5 feet south of fence, in root on north side of 18-inch oak tree; nail 808.49

T. 27 N., R. 4 E., in southwest quarter of section 35, at southwest corner of Y road, in field, 4 feet west of north and south fence, 5.3 feet south of east and west fence; iron post stamped "862".... 862.290

T. 27 N., R. 4 E., in southeast quarter of section 32, 150 feet east of iron bridge over (?) creek, south of road, in field, 4 feet south of fence, 4 feet east of a fence running off to south; iron post stamped "781" 780.987

	Feet.
T. 26 N., R. 3 E., in northwest quarter of section 2, at Y road, on west side of road at Y, in field, 4 feet northwest of corner fence post; iron post stamped "990"	989.992
T. 26 N., R. 3 E., corner of sections 8, 9, 16 and 17, at northwest corner of crossroads, in foundation of east wall 0.6 foot north of southeast corner of Dermda Center schoolhouse; aluminum tablet stamped "809"	809.204

FORMER SITE OF RUSH POST-OFFICE, WEST TO SCHAPVILLE, THENCE NORTH ONE AND A HALF MILES.

T. 28 N., R. 4 E., in southwest quarter of section 28, at northeast corner of crossroads (formerly "Rush post office"), in field, 3.5 feet east of fence, 4.5 feet north of fence, 1.5 feet west of small narrow ditch drain; iron post stamped "996"	995.731
T. 28 N., R. 4 E., in northwest quarter of section 29, north of road opposite T. Uren's house, in root on south side of lone oak tree; nail	969.59
T. 28 N., R. 3 and 4 E., about 0.25 mile south of corner of sections 19, 24, 25 and 30, at T road, north of road, in southwest corner of field, 4.5 feet east of fence, 4.5 feet north of fence; iron post stamped "932"	931.396
T. 28 N., R. 3 E., in southeast quarter of section 23, at southwest corner of T road, in root on north side of 48-inch elm tree; nail	708.78
T. 28 N., R. 3 E., in southeast quarter of section 22, north of road in field, 60 feet west of stone arch culvert, just east of gate to lane running north to house of L. Schultz, 2.5 feet north of fence; iron post stamped "766"	765.386
Schapville, in northeast quarter of section 30, T. 28 N., R. 3 E., at northwest corner of Y road, in east wall 14.4 feet north of southeast corner of Zion Presbyterian Church (German); aluminum tablet stamped "859"	859.030
T. 28 N., R. 3 E., in northeast quarter of section 19, 0.22 mile northwest of Y road, 3.7 feet below top in west face of north arch abutment wall to iron bridge; aluminum tablet stamped "731"	730.563

Cordova Quadrangle—Henry, Rock Island and Whiteside Counties.—The elevations in the following list are based on the Mississippi River Commission bench mark at Albany, a copper bolt in the west side of the southwest corner of foundation of brick store occupied by Hopper and Son, and marked "U. S. P. B. M." The elevation of this bench mark is accepted as 595.968 feet above mean sea level in accord with the 1907 adjustment. The leveling was done in 1896 by Mr. G. W. Newell, levelman.

This work was done prior to coöperation.

CORDOVA QUADRANGLE.

WHITESIDE COUNTY, ALBANY TOWNSHIP.

	Feet.
T 20 N., R. 2 E., sec. 1, fourth principal meridian, half section line, on south line; iron post stamped "678"	679.573

WHITESIDE COUNTY, NEWTON TOWNSHIP.

T. 20 N., R. 3 E., sec. 2, near northeast corner of southeast quarter of northeast quarter of, junction of roads on east line of section; iron post stamped "702"	703.586

WHITESIDE COUNTY, FENTON TOWNSHIP. Feet.

Fenton, south side of sidewalk, about 100 feet west of Chicago, Burlington & Quincy railroad; iron post stamped "621" (marked wrong, should be "602") 602.458

WHITESIDE COUNTY, ERIE TOWNSHIP.

Erie, small triangular park in public square; iron post stamped "587" 588.435

HENRY COUNTY, PHENIX TOWNSHIP.

T. 18 N., R. 3 E., sec. 12, northwest corner of northeast quarter of northwest quarter, junction of roads, 0.25 mile west of Sharon post-office; iron post stamped "597" 598.324

HENRY COUNTY, LORAINE TOWNSHIP.

T. 18 N., R. 4 E., sec. 6, near southeast corner of, junction of roads at William Ornett's (Sharon Stock Farm); iron post stamped "627" 628.228

ROCK ISLAND COUNTY, COE TOWNSHIP.

Hillsdale, 90 feet east of north end of Chicago, Burlington & Quincy railroad station; iron post stamped "598" (should be "578"...... 578.246

ROCK ISLAND COUNTY, ZUMA TOWNSHIP.

Joslin, northeast corner W. H. Whiteside's yard, by Chicago, Burlington & Quincy railroad; iron post stamped "581"........ 582.343
T. 19 N., R. 2 E., sec. 23, southeast corner of; iron post stamped "679" 680.426

Evanston, Highwood and Waukegan Quadrangles—Cook and Lake Counties.—The elevations in the following lists are based upon a Chicago City bench mark, a square cut on the corner of iron plate doorstep at foot of round iron pillar at northeast corner of two-story brick building at southwest corner of Lincoln and Foster avenues, the elevation of which is now accepted as 610.696 feet above mean sea level; they are also adjusted to agree with the corrected elevation of bench marks of the Chicago Sanitary District at Niles Center and DesPlaines. The corrected elevations are derived by adding 579.938 feet to the elevations given upon the Chicago City datum. The reference plane of which is the level of the city directrix, the zero of the lake gage and low water of 1847.

The leveling done in 1897 prior to coöperation was by Mr. E. S. Smith, levelman. In 1906 leveling was done by Mr. Henry Bucher, levelman, checking levels of 1897 on the Highwood quadrangle and extending levels through the Waukegan quadrangle.

The standard bench marks established by Mr. E. S. Smith are stamped "Chgo" in addition to figures of elevation in a few cases greatly in error. Those established by Mr. Bucher being stamped "Adj 1905" in addition to the figures of elevation.

Evanston Quadrangle.

CHICAGO NORTH VIA EVANSTON TO WINNETKA.

	Feet.
Chicago, southwest corner of Clark street and Pratt avenue, northeast corner of two-story brick building; base of iron column.....	604.126
About T. 44 N., R. 14 E., Evanston, Evanston City Hall, north side of east entrance, in face of stone work of 18-inches above sill; bronze tablet stamped "CHGO 601"	602.153
Winnetka, old town hall, 30 feet north of northeast corner of; iron post stamped "CHGO-651"	651.300

Highwood Quadrangle.

EVANSTON WEST TO EAST EDGE OF MAIN TOWNSHIP, THENCE NORTH TO SHERMANVILLE, THENCE EAST TO WINNETKA.

Niles Center, near southeast corner of St. Peters Church, projecting buttress front face of stone water table; bronze tablet stamped "CHGO 663"	623.397
T. 42 N., R. 12 E., road crossing on half section line between section 15 and 16, 0.75 mile south of Shermerville; iron post stamped "CHGO 650"	650.920

MORTO WEST VIA DES PLAINES TO SEC. 16, ELK GROVE TOWNSHIP, THENCE NORTH VIA ARLINGTON APTAKISIC AND HALF DAY TO SEC. 33 LIBERTY TOWNSHIP.

DesPlaines, southwest wing of north abutment of Chicago and North Western Railway bridge over DesPlaines river, on southwest corner of lower step; chiseled cross	630.908
DesPlaines, stone foundation east side of town hall; bronze tablet stamped "CHGO 642"	642.881
T. 41 N., R. 11 E., center of sec. 24, south of road at angle, 0.5 mile east of crossroads and 130 feet east of road to house of H. Beer, 0.6 feet north of fence and 2.5 feet east of north and south line fence; iron post stamped "666 ADJ 1905"	665.617
T. 41 N., R. 11 E., sec. 16, northeast quarter of, at southeast corner of cheese factory, south face of brickwork near foundation; bronze tablet stamped "716 ADJ 1905"	715.922
T. 42 N., R. 11 E., sec. 29, Arlington Height high school building (old), front face of stone water table, at southwest corner of front projection; bronze tablet stamped "704 ADJ 1905"	703.820
T. 42 N., R. 11 E., sec. 8, northwest corner, 0.25 miles east of, T road to south, at southwest corner of T on west side of road, 8.4 feet south of fence corner and 1 foot east of fence; iron post stamped "705 ADJ 1905"	705.137
T. 43 N., R. 11 E., southeast quarter, 0.5 mile south of Aptakisic, 9 feet south of forks of road, west side of road, 15 feet east of wire fence; iron post stamped "682 ADJ 1905"	681.566
Aptakisic, crossing of Wisconsin Central Railroad, top of southwest rail	685.4
T. 43 N., R. 11 E., sec. 15, Half Day school building, front face of northwest corner of foundation; bronze tablet stamped "669 CHGO"	667.628
T. 43 N., R. 11 E., sec. 15, Dalf Day, bridge over Indian Creek, at southwest corner of, top of stone abutment, 6 feet southwest of end of iron truss; aluminum tablet stamped "654 ADJ 1905".....	653.640
T. 44 N., R. 11 E., sec. 34, near southwest corner of, crossroads, 1400 feet east of, on south side of, south side of road, 9.7 feet west of southwest corner of iron truss of wagon bridge over DesPlaines river; primary traverse post No. 13 stamped "651 ADJ 1905".....	650.883

HALF DAY EAST TO ROAD CROSSING, CHICAGO, MILWAUKEE AND ST. PAUL RAILROAD IN SECTION 17, WEST DEERFIELD TOWNSHIP, THENCE NORTH AND EAST TO LAKE FOREST.

	Feet.
T. 43 N., R. 12 E., sec. 17, southwest quarter of, water subway under Chicago, Milwaukee & St. Paul railroad, at road crossing, east face, at northeast corner of stone work; bronze tablet stamped "667 ADJ 1905" (see foot note)	667.017
T. 43 N., R. 12 E., sec. 7, Everett station, in front of; top of rail	680.7
T. 44 N., R. 12 E., sec. 31, southeast corner, 0.2 mile west of, and road to east, at southeast corner and on south side of road, 50 feet east of fence corner, 1 foot north of fence; iron post stamped "675 ADJ 1905"	675.139
Durpath, T. 44 N., R. 12 E., sec. 32, at crossing of Chicago & Northwestern railroad; top of rail	674.1

Note—The elevation of this bench mark is checked also by old line from Shermerville.

Waukegan Quadrangle.

SECTION 33, LIBERTY TOWNSHIP, NORTH VIA LIBERTYVILLE TO ROSECRANS, THENCE EAST AND SOUTH TO ZION CITY AND SOUTH TO LAKE FOREST.

T. 44 N., R. 11 E., sec. 33, in northeast quarter of; top of rail at crossing of Elgin, Joliet & Eastern railroad	673.5
Libertyville station, T. 44 N., R. 11 E., sec. 21, crossing of Chicago & Milwaukee Electric railroad; top of rail	699.0
Libertyville, T. 44 N., R. 11 E., sec. 16, in town hall, east front, at southeast corner of building, in stone foundation 1.3 feet above ground; aluminum tablet stamped "698 ADJ 1905"	698.173
Libertyville, T. 44 N., R. 11 E., sec. 16, Chicago, Milwaukee & St. Paul railroad station, in front of; top of rail	692.4
T. 44 N., R. 11 E., sec. 4, west quarter corner, 0.2 mile east of, T road west, on east side of road, opposite T, on line with east and west fence line, 1.2 feet west of fence and 45 feet south of telegraph pole; iron post stamped "660 ADJ 1905"	659.431
T. 45 N., R. 11 E., sec. 32, in northwest quarter of, T. road south, southeast corner of, on east side of road, 2.1 feet west of old fence line and 21 feet south of new east and west fence line; iron post stamped "766 ADJ 1905"	765.949
T. 45 N., R. 11 E., sec. 20, east quarter corner of, crossroads, at northwest corner of, in school yard, on north side of road inside of fence line, 1 foot north of fence and 4.2 feet west of fence corner, at southeast corner of school yard; iron post stamped "760 ADJ 1905"	759.773
T. 45 N., R. 11 E., sec. 5, east quarter corner of, crossroads at northeast corner, on north side of road, 40 feet east of fence corner, 1 foot south of fence; iron post stamped "720 ADJ 1905"	719.437
T. 46 N., R. 11 E., sec. 29, north quarter corner of, crossroads, southeast corner of, east side of road, 20 feet south of fence corner, 1.2 feet west of fence; iron post stamped "713 ADJ 1905"	762.518
T. 46 N., R. 11 E., sec. 16, center of, crossroads at Rosecrans, at northwest corner of, on north side of road, 1 foot south of fence, 11 feet west of fence corner; iron post stamped "722 ADJ 1905"	722.230
T. 46 N., R. 11 E., sec. 15, near center of, crossing of Chicago, Milwaukee and St. Paul Railroad; top of rail	697.8
T. 46 N., R. 11 E., sec. 14, east quarter corner of, crossroads, at southeast corner, on east side of road and 8 feet south of fence corner; iron post stamped "701 ADJ 1905"	700.974

	Feet.
T. 46 N., R. 11 E., sec. 13, west quarter corner, 0.3 mile east of, crossing of Chicago and North Western Railroad; top of rail	695.8
T. 46 N., R. 12 E., sec. 18, 0.3 mile west of, crossroads, at northwest corner of, on north side of road (on bank), 2.3 feet south of old board fence, and 14.5 feet west of east line of fence; iron post stamped "714 ADJ 1905"	713.751
T. 46 N., R. 12 E., sec. 21, Zion City, crossing of Chicago and North Western Railroad; top of rail	630.3
T. 46 N., R. 12 E., sec. 21, southeast corner of, crossroads at Lake Mound Cemetery, Zion City, southeast corner of crossroads, east side of road, 1 foot west of cemetery fence; iron post stamped "633 ADJ 1905"	632.519
T. 45 N., R. 12 E., sec. 4, southeast corner, 0.2 mile west of, T road to west, at southwest corner of T, south side of road, 1.2 feet north of fence, 9 feet west of fence corner; iron post stamped "647 ADJ 1905"	646.570
T. 45 N., R. 12 E., sec. 16, east quarter corner, 0.3 mile west of T road to west, northwest corner of T, top of fire plug, Sheridan Road and Glen Flora Avenue	642.970
Waukegan, northeast corner of stone window sill, in east front of Lake County Courthouse (City bench marks, no marks)	664.115
Waukegan, T. 45 N., R. 12 E., sec. 21, Lake County Courthouse, east entrance, in stone base of two columns, on north side of entrance; aluminum tablet stamped "669 ADJ 1905"	668.387
T. 45 N., R. 12 E., sec. 4, northwest quarter of, 18th street station Chicago, Milwaukee Electric Railroad, Elgin, Joliet and Eastern Railroad bridge over Chicago and North Western, C. & M. Electric Railroad and wagon road, west abutment wall, in top of projection of bottom course of masonry, 4.2 feet north of south end of wall and 1.5 feet above pavement; aluminum tablet stamped "659 ADJ 1905"	658.935
T. 44 N., R. 12 E., sec. 20, Lake Bluff, Chicago and North Western Railroad, bridge over wagon road and Chicago and Milwaukee Electric road, south of station, in top of stone foundation wall supporting iron column, between Electric (Libertyville branch), and wagon road, in top of wall, 3 feet northwest of southeast end of; aluminum tablet stamped "671 ADJ 1905"	670.778
T. 44 N., R. 12 E., sec. 33, Lake Forest, at southeast corner of city hall grounds; iron post stamped "Prim. Trav. Post. No. 12-713-ADJ-1905"	712.913

Wheaton Quadrangle—DuPage County.—The elevations in the following list upon bench marks established at Bartlett and Roselle by the U. S. Army Engineers, and upon the 1907 adjustment datum.

The leveling was done in 1905 by Mr. R. C. Howard.

The work was done in coöperation with the State and the standard bench marks are stamped with the State name.

WHEATON QUADRANGLE.

BARTLETT SOUTH ALONG HIGHWAYS TO WEST CHICAGO, THENCE EAST BY CHICAGO AND NORTHWESTERN RAILWAY TO GLEN ELLYN, THENCE NORTH ALONG HIGHWAY AND CHICAGO AND GREAT WESTERN RAILWAY TO ROSELLE.

	Feet.
Bartlett, U. S. A. Engineers B. M. No. 89, 150 meters northwest of station; 100 meters north of Chicago, Milwaukee & St. Paul Ry. track, in stone foundation of Congregational Church, center of copper bolt leaded horizontally on east face of southeast corner	804.055

	Feet.
T. 40 N., R. 9 E., near northeast cor. sec. 9, stone bridge over small stream; in southeast corner of east wall; aluminum tablet stamped "787 ILLINOIS 1905"	787.419
Ingalton T. 40 N., R. 9 E., cor. secs. 27, 28, 33 and 34, 0.25 mile west of, Ingalton schoolhouse, south wall, southwest corner; aluminum tablet stamped "795 ILLINOIS 1905"	794.837
West Chicago, City Hall, east wall, 2 feet from southeast corner; aluminum tablet stamped "784 ILLINOIS 1905"	784.078
Winfield, 150 feet east of station, 75 feet south of C. & N. W. Ry., stone culvert, east side of road; aluminum tablet stamped "727 ILLINOIS 1905"	726.667
Wheaton, courthouse, north side of west entrance; aluminum tablet stamped "753 ILLINOIS 1905"	752.878
Glen Ellyn, high school, north wall, 6 feet west of entrance; aluminum tablet stamped "766 ILLINOIS 1905"	766.058
Bloomingdale, Kolbusch & Hauseminn store building, west wall, 35 feet south of north wall; aluminum tablet stamped "771 ILLINOIS 1905"	771.127
Roselle, Du Page Co., Ill., on southeast corner of Chicago St. and road crossing it, in north face of foundation wall of brick business building of Mathew Secker, standing about 80 meters north of track, center of copper bolt leaded horizontally, 3 feet from northeast corner and 2 feet above ground (Army Engineers P. B. M. 90)	772.156

GLEN ELLYN SOUTH ALONG HIGHWAYS TO LISLE, THENCE WEST AND NORTH BY NAPERVILLE AND WARRENHURST TO WEST CHICAGO.

T. 39 N., R. 10 E., sec. 35, near southwest corner northwest quarter of, west side, south abutment, small bridge; aluminum tablet stamped "697 ILLINOIS 1905"	697.502
Lisle, 0.2 mile west of, C. B. & Q. Ry. bridge over east branch Du Page River, east abutment, north side; aluminum tablet stamped "674 ILLINOIS 1905"	674.469
Naperville, in front of station; top of rail	715.5
Naperville, Nicholas Library Building, southeast corner Van Buren Ave., and Washington street, west wall, northwest corner; aluminum tablet stamped "693 ILLINOIS 1905"	693.310
T. 38 N., R. 9 E., sec. 16, near southeast corner of northeast quarter; rock culvert, east abutment, north side; aluminum tablet stamped "697 ILLINOIS 1905"	697.311
Warrenhurst, 275 feet east of railway track, 50 feet north of road, south wall, rock foundation Daw Bros. house, 10 feet west of southeast corner; aluminum tablet stamped "732 ILLINOIS 1905"	732.328

AT ITASKA.

Itaska, 80 meters north of track of C. M. & St. P. R. R., in a northeasterly direction from station, in east foundation wall frame store building of Dr. E. Smith; being center of copper bolt leaded horizontally, 2 feet from southeast corner (Army Engineers P. B. M. 91)	699.107

Hennepin, LaSalle and Toluca Quadrangles—Bureau, LaSalle and Putnam Counties.—The elevations in the following list are based upon the U. S. Army Engineers' precise level line along the Illinois river, and upon the 1907 adjustment datum.

The leveling was done in 1903 by Henry Bücher.

The work was done in coöperation with the State and the standard bench marks are stamped with the State name.

Hennepin Quadrangle.

TWO MILES WEST OF GRANVILLE, VIA HENNEPIN, TO CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD NEAR BUREAU.

	Feet.
T. 32 N., R. 1 W., 0.12 mile west of quarter corner between sections 7 and 8, at southeast corner of T road, on line of east and west fence, 13.7 feet east of north and south fence line; iron post stamped "Prim. Trav. Sta. No. 5 690"	690.677
T. 32 N., R. 2 W., 0.25 mile west of quarter corner between sections 11 and 12, southwest corner of crossroads, west of road, 14.6 feet south of fence corner, 1.1 feet east of fence; iron post stamped "556"	555.946
Hennepin courthouse, southeast corner of grounds, 2.5 feet north of hitching rack; iron post stamped "Prim. Trav. Sta. No. 13 505"	505.407
Hennepin, on west bank of Illinois River, 90 feet north of road, near edge of water, in root of large cottonwood tree; railroad spike	443.42
Permanent Bench Mark 69, Illinois River Survey	462.792

BUREAU SOUTHWEST, TO SOUTHWEST CORNER SEC. 29, T. 15 N., R. 9 E., THENCE NORTH, TO PRINCETON, THENCE NORTHEAST ALONG DOVER ROAD ABOUT 4 MILES, THENCE EAST, TO SECOND CROSSING CHICAGO, BURLINGTON AND QUINCY RAILROAD.

Temporary Bench Mark, Illinois River Survey } check line between benches.	472.386
Permanent Bench Mark 69, Illinois River Survey } check line between benches.	462.792
T. 15 N., R. 9 E., southwest quarter of section 25, in northwest angle of road, in fence line, in root of lone oak tree; nail	648.93
T. 15 N., R. 9 E., quarter corner between sections 26 and 35, T road at schoolhouse district No. 174, northwest corner of school yard, opposite T road, 14 feet east of fence corner; iron post stamped "656"	655.744
T. 15 N., R. 9 E., quarter corner between sections 27 and 34, southwest corner of T road, at fence corner, in root on north side of hard maple tree; nail	654.86
T. 15 N., R. 9 E., northeast corner of section 32, 350 feet east of T road, in top 1.8 feet from east end of north wall of concrete culvert; chiseled square	633.34
T. 15 N., R. 9 E., northeast corner of section 31, southeast corner of crossroads, south of road, on line of east and west fence; iron post stamped "Prim. Trav. Sta. No. 12 687"	687.351
T. 15 N., R. 9 E., in southeast quarter of section 7, northeast corner of T road, 4.9 feet east of fence corner; iron post stamped "512"	511.536
T. 15 N., R. 9 E., near northwest corner of section 8, west of road, in yard of W. H. Bryant, 100 feet south of northeast fence corner, in spread root 2.5 feet east of trunk of oak tree; nail	639.17
T. 16 N., R. 9 E., center of section 32, at southeast corner of T road, on east side of road, 10 feet south of fence corner; iron post stamped "686"	685.645
T. 16 N., R. 9 E., in southeast quarter of section 29, near southwest corner of school yard on east side of T road, in root of maple tree; nail	696.91
Princeton, Bureau County Courthouse, in southeast corner of grounds, 35.7 feet north of curb line around south edge of grounds (South street), 3.6 feet west of west edge of concrete walk along east side of grounds (Second street); iron post stamped "719"	718.767
T. 15 N., R. 9 E., 0.1 mile west of quarter corner between sections 3 and 10, northeast corner of crossroads, in Meyers (?) school yard; iron post stamped "735"	735.452
T. 16 N., R. 9 E., northwest corner of section 2, 0.25 mile east of, at northeast corner of crossroads, in field, in root at southwest side of lone soft maple tree; nail	730.77

T. 16 and 17 N., R. 9 and 10 E., township corner, southeast corner of crossroads, east of road, 25 feet south of fence corner, 1 foot west of fence; iron post stamped "715" 714.827
T. 16 and 17 N., R. 10 E., corner of sections 5, 6, 31 and 32, southwest corner of T road, in field, in north side in root of large soft maple tree nearest to fence corner; nail 698.84
T. 16 N., R. 10 E., northern boundary of section 3, quarter corner, southeast of junction of two T roads, 25 feet east of fence corner, 1 foot north of fence; iron post stamped "728" 727.546
T. 16 and 17 N., R. 10 and 11 E., township corner, north side of T road, 26 feet west of fence corner opposite T, 1.2 feet south of fence; iron post stamped "687" 686.699
T. 16 N., R. 11 E., northeast corner of section 6, southwest corner of crossroads, in school yard, near fence corner, in root on northwest side of large soft maple tree; nail 678.75

PRINCETON NORTHWEST AND NORTH, THENCE EAST, VIA LIMERICK, TO PRINCE SCHOOL.

T. 16 N., R. 9 E., near quarter corner between sections 4 and 5, 50 feet north of Y road, in field on east side of road, in top of concrete wall; chiseled square; marked "671.8" 671.78
T. 17 N., R. 9 E., quarter corner between section 29 and 32, southwest corner of Y road, south of road, 39 feet west of fence corner, 1.3 feet north of fence; iron post stamped "669" 669.224
T. 17 N., R. 9 E., west of quarter corner between sections 18 and 19, northwest corner of Y road, north of road, 12.5 feet west of fence corner, 1 foot south of fence; iron post stamped "693" 692.539
T. 17 N., R. 9 E., quarter corner between sections 6 and 7, southwest corner of crossroads, in root on northwest side of soft maple tree 18 inches in diameter, nail; marked "G. S. B. M. 717.8" 717.80
T. 17 N., R. 9 E., north quarter of section 6, southeast corner of T road, 1.9 feet northwest of corner fence post; iron post stamped "Prim. Trav. Sta. No. 10, 740" 739.661
Limerick, 0.25 mile east of northwest corner of section 4, T. 17 N., R. 9 E., at crossroads, 20 feet east of fence corner, south of road, in yard, in root on northwest side of 30-inch soft maple tree; nail; marked "733.3" 733.41
T. 17 N., R. 9 E., northwest corner of section 2, at northwest corner of crossroads, north of road, 26 feet west of large soft maple tree at fence corner, 0.7 foot south of fence; iron post stamped "736" 735.987
T. 17 and 18 N., R. 9 and 10 E., township corner, at T road, west of road, in field, in root on east side of oak tree 26 inches in diameter, nail; marked "G. S. B. M. 738.2" 738.33
T. 17 N., R. 10 E., northwest corner of section 5, at southeast corner of crossroads, 1.3 feet northwest of fence corner; iron post stamped "Prim. Trav. Sta. No. 9, 749" 748.858
T. 17 N., R. 10 E., just east of northwest corner of section 1, at southwest corner of crossroads, south of road, 11.6 feet west of fence corner, 2.3 feet north of fence; iron post stamped by mistake "726" 767.218
T. 17 N., R. 11 E., near northwest corner of section 6, 5 feet from west end of north wall of concrete culvert; chiseled square 764.02

INTERSECTION OF TOWNSHIP LINE WITH PRINCETON-DOVER ROAD NORTH, TO CHICAGO, BURLINGTON AND QUINCY RAILROAD.

T. 17 N., R. 9 E., quarter corner between sections 26 and 27, northwest corner of crossroads, in house yard, in root on southeast side of 16-inch hard maple tree nearest fence corner, nail; marked "698.5" 698.39

	Feet.
T. 17 N., R. 9 E., northeast of west quarter of section 23, center of triangle at Y road, in root on southwest side of 18-inch ash tree, nail; marked "708.9"	708.83
T. 17 N., R. 9 E., corner of sections 2, 3, 10 and 11, northeast corner of crossroads, west side of school yard, in root on west side of 24-inch elm tree nearest to southwest corner of yard, nail; marked "721.9"	721.75

LASALLE QUADRANGLE.

FROM NORTHWEST CORNER SEC. 5, T. 16 N., R. 11 E., EAST ALONG HIGHWAY FOR 12 MILES, THENCE SOURH, VIA UTICA, TO LOWELL, THENCE WEST, VIA TICONA, TO GRANVILLE.

(*For Ticona see Toluca Quadrangle.*)

T. 16 N., R. 11 E., corner of sections 4, 5, 32 and 33, at crossroads, at northeast corner of iron bridge over Negro creek, on top of concrete abutment, chiseled square; marked "653.7"	653.64
T. 16 N., R. 11 E., corner of sections 3, 4, 33 and 34, at junction of two T roads, north of road, opposite T, 54 feet west of fence corner at northwest corner of junction of two T roads, 1.3 feet south of fence; iron post stamped "675"	674.808
T. 16 N., R. 11 E., northeast corner of section 1, northwest corner of T road, 12.5 feet west of fence corner, 1.1 feet south of fence; iron post stamped "663"	663.265
T. 34 N., R. 1 E., 0.6 mile west of corner of sections 17 ,18, 19 and 20, at northeast corner of small iron bridge over Spring creek, on top of stone abutment 2.5 feet southwest of northeast corner and 0.4 foot from west edge; chiseled square	640.68
T. 34 N., R. 1 E., corner of sections 15, 16, 21 and 22, at northwest corner of crossroads, in southeast corner of Center schoolhouse District No. 175 yard, 17 feet west of fence corner, 1.2 feet north of fence; iron post stamped "659"	658.869
T. 34 N., R. 1 E., east of corner of sections 14, 15, 22 and 23, northeast corner of iron bridge over Vermilion river, on top of east end of wing wall, chiseled square; marked "G. S. B. M."	599.90
T. 34 N., R. 1 E., 0.16 mile east of corner of sections 13, 14, 23 and 24, south end of east concrete abutment to bridge over Tomahawk creek, on top of bridge seat, 0.7 foot south of south edge of truss, 0.7 foot east of west edge of abutment, chiseled square; marked "613"	612.78
T. 34 N., R. 2 E., corner of sections 17, 18, 19 and 20, 100 feet east of crossroads, in yard on south side of road, in root on northeast side of 24-inch poplar tree; nail	683.58
T. 34 N., R. 2 E., corner of sections 16, 17, 20 and 21, southeast corner of crossroads, south of road, 3.5 feet east of fence corner, 0.9 foot north of fence; iron post stamped "640"	640.095
T. 34 N., R. 2 E., 0.25 mile south of corner of sections 20, 21, 28 and 29, on top of concrete abutment at southwest corner of bridge over Peumsaugum creek; chiseled square	595.91
T. 33 N., R. 2 E., quarter corner between sections 4 and 5, at northwest corner of crossroads, on line of fence running east and west, 3.7 feet east of fence corner; iron post stamped "Prim. Trav. Sta. No. 8, 619"	619.081
T. 33 N., R. 2 E., west of east quarter corner of section 8, west of Y road, on top of masonry abutment near northeast corner of small bridge, chiseled square; marked "496.8"	496.63

	Feet.
Utica, about 1 mile south of, on top of northeast end stone of lowest stepped course below bridge seat of east wing wall of north stone abutment of Utica bridge over the Illinois river, chiseled square; marked "U.[]S."	454.645
T. 33 N., R. 2 E., southeast quarter of section 18, 1.3 miles west of Utica bridge over Illinois river, near junction of river road and road to Utica, 2.33 feet west of east fence of north and south road, 66.7 feet north of center of wagon track of river road, 61.5 feet north of junction of above mentioned fence with north fence of river road, 16.5 feet north of small box elder tree; stone, pipe and cap { Elevation of bolt in stone	451.421
Elevation of cap	455.376
Utica, 1 mile south of, in top of concrete cap of first pier south of north end of wagon bridge over Illinois river; aluminum tablet stamped "468"	467.707
T. 33 N., R. 2 E., quarter corner between sections 32 and 33, in southwest corner of Clayton School District No. 169 yard, opposite center of T road, 7.8 feet east of old fence corner, 1.1 feet north of old fence; iron post stamped "651"	650.559
T. 32 N., R. 2 E., quarter corner between sections 4 and 5, lane to east and road angle to southwest, in center of triangle, in root on northwest side of 18-inch hickory tree, nail; marked "647.3"	647.33
T. 32 N., R. 2 E., southeast quarter of section 8, in top of southeast corner of concrete wing wall of iron bridge over Vermilion river, 0.8 foot southeast of north edge and 0.1 foot west of east edge; chiseled square	533.84
Lowell, 0.25 mile south of, 0.25 mile south of corner of sections 8, 9, 16 and 17, T. 32 N., R. 2 E., at northwest corner of crossroads, 1.5 feet east of fence line, 1.8 feet south of fence line, 1.8 feet southeast of fence corner; iron post stamped "Prim. Trav. Sta. No. 7, 632"	631.623
T. 32 N., R. 2 E., near center of section 17, 100 feet northeast of T road, in top of stone abutment at southeast corner of iron bridge, chiseled square; marked "636.5"	636.65
T. 32 N., R. 1 E., 0.13 mile west of corner of sections 11, 12, 13 and 14, 100 feet west of center of Illinois Central Railroad, south of road, 10 feet east of small wild cherry tree, 0.8 foot north of fence; iron post stamped "665"	665.334
T. 32 N., R. 1 E., quarter corner between sections 10 and 15, at northeast corner of T road, in yard, in root on west side of 19-inch box elder tree near fence corner, nail; marked on fence "669.0"	669.22
T. 32 N., R. 1 E., northwest corner of section 16, southeast corner of crossroads, east of road, 1.8 feet south of fence corner 1.4 feet west of fence; iron post stamped "Prim. Trav. Sta. No. 6, 668"	668.487
T. 32 N., R. 1 E., corner of sections 7, 8, 17 and 18, 150 feet west of crossroads, south of road, in root on north side of large branching elm tree, nail; marked "G. S. B. M."	679.14
T. 32 N., R. 1 W., at quarter corner east side of section 12, at T road, south of road, 20 feet west of fence corner, 1 foot north of fence; iron post stamped "679"	679.431
Standard, at southeast corner of crossroads at, quarter corner between sections 11 and 12, T. 32 N., R. 1 W., in front of E. W. Berta's saloon, 0.1 foot east of curb edge and on line with north line of saloon building, on concrete pavement, chiseled square; marked "684.1"	684.12
T. 32 N., R. 1 W., quarter corner between sections 9 and 10, at crossroads at southeast corner of GranvilleChicago-Milwaukee and St. Paul Railroad crossing, just north of grain elevator and foundry and machine shops, north of road, 22 feet west of fence corner, 1 foot south of fence; iron post stamped "688"	688.060

	Feet.
T. 32 N., R. 1 W., east of center of section 9, south of road, in field, east of main north and south street in Granville, in root on west side of 24-inch maple tree, nail; marked "689.8"	689.80
T. 32 N., R. 1 W., quarter corner between sections 8 and 9, 0.25 mile west of, southwest corner of T road, in house yard near fence corner, in root on northwest side of 13-inch ash tree, nail; marked on fence "717.0"	717.12

PRICE SCHOOL, EAST TO TRIUMPH, THENCE SOUTH TO ABOVE LINE.

T. 17 N., R. 11 E., northwest corner of section 4, southeast corner of crossroads at Price school, road by school house; iron post stamped ("776" Prim. Trav. Sta. No. 3)	775.354
T. 17 N., R. 11 E., northwest corner of section 1, southwest corner of T road, south of road, 22.4 feet west of fence corner, 1.4 feet north of fence; iron post stamped "722"	721.402
T. 35 N., R. 1 E., northeast corner of section 20, northwest corner of crossroads, 7 feet west of hedge corner, 2 feet south of hedge, 2.6 feet west of telephone pole; iron post stamped "Prim. Trav. Sta. No. 2, 703"	707.709
T. 35 N., R. 1 E., 0.25 mile west of center of section 23, southwest corner of crossroads, 1 foot south of north end of concrete step at entrance on east side of Christian church, 1 foot east of building; aluminum tablet stamped "684"	684.340
T. 35 N., R. 1 E., center of section 24, 180 feet east of T road, in top of concrete wing wall near west edge of abutment at southwest corner of small iron bridge, chiseled square; marked "650.2"	650.15
Triumph, in concrete walk at northwest corner of First National Bank, 0.5 foot west of building and 0.8 foot south of north edge of building; aluminum tablet stamped "Prim. Trav. Sta. No. 1, 670"	670.601
T. 35 N., R. 2 E., northwest corner of section 28, southeast corner of crossroads, in root on south side of 31-inch cottonwood tree, nail; marked "657.0"	656.99
T. 34 N., R. 2 E., northeast corner of section 5, southwest corner of junction of two T roads, south of road, 9.5 feet west of fence corner, 1.1 feet north of fence; iron post stamped "673"	672.676
T. 34 N., R. 2 E., quarter corner between sections 4 and 5 southwest corner of crossroads, in root on north side of 47-inch cottonwood tree, nail; marked "706.5"	706.50
T. 34 N., R. 2 E., northeast corner of section 20, southwest corner of crossroads, on top of concrete culvert; chiseled square	640.10

FOUR CORNERS AT NEGRO CREEK, NORTH, VIA ARLINGTON, TO PRICE SCHOOL.

T. 16 N. and 17 N., R. 11 E., corner of sections 4, 5, 32 and 33, on abutment of bridge over Negro creek; chiseled square	653.64
T. 17 N., R. 11 E., quarter corner between sections 20 and 21, at north side of crossroads, at southeast corner of small iron bridge, on I beam embedded in edge of small concrete abutment, chiseled cross; marked "685.7"	685.53
T. 17 N., R. 11 E., quarter corner between sections 16 and 17, southwest corner of crossroads, south of road, 22 feet west of fence corner, 1.2 feet north of fence; iron post stamped "724"	723.522

PERU SOUTH, TO CEDAR POINT.

Peru, at foot of Marion street, in top of bridge seat course of pier at north end of draw span of highway bridge over Illinois river, 1.3 feet from north face and 1.25 feet from west end of pier; top of copper bolt; marked "U. S. (.) P. B. M." (U. S. Army Engineers' bench mark)	458.954

	Feet.
T. 33 N., R. 1 E., near southeast corner of section 20, on top near northeast corner of first course of masonry below bridge seat of abutment at southeast corner of iron bridge over slough; chiseled square	458.33
T. 33 N., R. 1 E., center of section 32, northwest corner of T road, west of road, 1.2 feet east of fence, 32 feet north of east and west fence line on north side of road; iron post stamped "645"	645.433
T. 32 N., R. 1 E., near east quarter corner of section 5, on top of masonry abutment near northwest corner of small iron bridge; chiseled square	625.29

Toluca Quadrangle.

LOWELL TO TICONA, THENCE NORTHWEST.

Ticona station, in southeast quarter of section 24, T. 32 N., R. 1 E., at road crossing on Chicago, Burlington and Quincy Railroad, southeast side of road, 95 feet northeast of center of track, 11 feet northeast of old fence corner, 1 foot northwest of old fence, 22.5 feet northeast of telephone pole; iron post stamped "645"	645.040
T. 32 N., R. 1 E., quarter corner between sections 13 and 24, east of T road, inside fence, at north edge of woods, the nearest tree to gate and farthest north, in root on west side of 25-inch oak tree, nail; marked on fence "660.5"	660.64

Peoria Quadrangle—Peoria and Tazewell Counties.—The elevations in the following list are based upon an aluminum tablet in the west side of Bradley Polytechnic Institute building, Peoria, Illnois, stamped "607 Peoria," the elevation of which is determined to be 607.749 feet above mean sea level.

The initial points from which the corrected elevations have been obtained are the standard bench marks at Pekin and Mackinaw river bridge, whch have been recovered by the recent precise level lines of the Army Engineers along the Illinois river. The correction applying at Pekin to the engineers' figures based upon the "Memphis" datum, is 6.892 feet, to accord with the 1907 adjustment.

The leveling was done in 1902 by Mr. Carleton McRae, levelman.

This work was done prior to coöperation.

Standard bench marks set in the course of this work are stamped mostly one foot lower than the corrected values.

Peoria Quadrangle.

PEORIA WEST ALONG FARMINGTON ROAD 7 MILES, THENCE SOUTH 4 MILES, THENCE EAST TO HOLLIS, THENCE NORTHEAST TO PEORIA.

Peoria, water gage at foot of Bridge street; gage mark reading 130 feet below Lake Michigan	451.42
Peoria, Bradley Polytechnic Institute, in west side of; aluminum tablet stamped "607 PEORIA"	607.599
Peoria, 7 miles west of; at crossroads, north limestone M. E. church, in middle of west foundation; bronze tablet stamped "708 PEORIA"	708.733
Hollis township, on line between sections 4 and 5, 200 yards west of north and south road, 300 yards north of T road to east, in northwest corner of foundation of C. F. Goetze house; aluminum tablet stamped "622 PEORIA"	622.712

PEORIA TO POINT 25 MILES EAST OF UPPER FREE BRIDGE, THENCE SOUTH TO FARMINGDALE, THENCE WEST TO PEORIA.

	Feet.
Peoria, 6.25 miles northeast of, 2.5 miles east of Free Bridge, house of J. Grosenbach, water tank at foundation of, east side of; bronze tablet stamped "693 PEORIA"	693.804

FARMINGDALE SOUTH TO GROVELAND, THENCE WEST TO PEKIN.

Groveland, southwest corner of Baptist Church; aluminum (?) tablet stamped "778 PEORIA"	778.768

HOLLIS SCHOOL NO. 4 SOUTH TO MAPLETON, THENCE EAST TO PEKIN, THENCE NORTH TO HOLLIS STATION, THENCE RETURN TO PEKIN.

Groveland, southwest corner of Baptist Church; aluminum (?) tablet of steel wagon bridge over Big LaMache creek	455.39
Pekin, Catch Basin, in northeast corner of County Clerk's Office, in courthouse grounds; aluminum (?) tablet stamped "478 PEORIA" (Elevation by Army Engineers 485.973 MEMPHIS DATUM)	479.081

PEKIN SOUTHWEST ALONG RIVER ROAD TO MACKINAW RIVER BRIDGE, THENCE SOUTH 4 MILES, THENCE EAST TO NEAR HAWLEY, THENCE NORTH TO PEKIN.

Mackinaw River Bridge (iron), on south wing of west abutment; aluminum tablet (?) stamped "453 PEORIA" (Elevation by Army Engineers, 461.205, Memphis datum)	454.313
Hawley station, 0.65 mile east of, on southeast wing of abutment of wagon bridge over north and south road; aluminum tablet stamped "513 PEORIA"	513.802

HAWLEY NORTHEASTERLY TO GROVELAND.

Hawley, 1 mile south and 0.5 mile east of; iron bridge over small branch, south wing of east abutment; aluminum tablet stamped "511 PEORIA"	511.579
Groveland, 6 miles south of, 1.5 miles west of Tremont, wagon bridge on east and west road, east abutment, north wing; aluminum tablet stamped "611 PEORIA"	612.185

Mahomet and Urbana Quadrangles—Champaign and Piatt Counties.—The elevations in the following list depend on a bench mark established by a precise line of levels at Champaign fifty-three feet southeast of southeast corner of Engineering building, University of Illinois, iron post stamped "Prim. Trav. Sta. No. 1," its accepted elevation being 721.103 feet, as determined by the 1907 adjustment.

The leveling was done in 1905 by Mr. R. C. Howard, levelman.

The work was done in coöperation with the State and the standard bench marks are stamped with the State name.

URBANA QUADRANGLE.

URBANA ALONG HIGHWAY EAST TO CHAMPAIGN AND SOUTH AND EAST TO PHILO.

Champaign, University of Illinois, southeast corner of Engineering Hall; iron post stamped "Prim. Trav. Sta. No. 1 F"	721.103
T. 18 N., R. 9 E., northwest corner sec. 6; southeast angle of crossroads; iron post stamped "717 ILLINOIS 1905"	717.926

Feet.

T. 18 N., R. 9 E., southwest corner sec. 17, north side, east abutment bridge; aluminum tablet stamped "680 ILLINOIS 1905".......... 680.345

Philo, Philo Exchange Bank, east side water table 12 feet south of wall; aluminum tablet stamped "737 ILLINOIS 1905"............ 736.833

PHILO ALONG HIGHWAY EAST AND NORTH TO ST. JOSEPH, THENCE WEST TO URBANA.

Sidney, high school, south side, southwest corner; aluminum tablet stamped "673 ILLINOIS 1905"................................... 672.576

T. 19 N., R. 10 E., cor. secs. 27, 28, 33 and 34, 0.25 mile east of; south abutment, west side iron bridge over Salt River; aluminum tablet stamped "655 ILLINOIS 1905".................................. 655.104

T. 19 N., R. 10 E., northeast corner sec. 15, 0.6 mile west of St. Joseph, west abutment north side bridge over Salt River; aluminum tablet stamped "663 ILLINOIS 1905"...................... 662.702

Mayview station, 0.1 mile east of, T. 19 N., R. 10 E., sec. 8, southwest corner of; southwest corner intersection road, concrete right of way post marked "P. & E. property line," west side post; aluminum tablet stamped "681 ILLINOIS 1905"...................... 680.715

Mayview, in front of station; top of north rail..................... 686.

ST. JOSEPH NORTH ALONG HIGHWAY TO SECTION 2, T. 20 N., R. 10 E., THENCE WEST ON TOWNSHIP LINE TO SEC. 6, T. 20 N., R. 9 E., THENCE SOUTH TO CHAMPAIGN.

T. 20 N., R. 10 E., near center of line between secs. 22 and 23, B. F. Youman's house, west of road, in south wall, brick foundation; aluminum tablet stamped "676 ILLINOIS 1905".................. 676.013

T. 20 N., R. 10 E., secs. 2, 3, 10 and 11, 0.25 mile south of corner, east of road, Henry Dintsman's house, south side, brick foundation; aluminum tablet stamped "677 ILLINOIS 1905"........... 677.446

T. 21 N., R. 10 E., southwest corner sec. 32, west side, north abutment bridge; aluminum tablet stamped "688 ILLINOIS 1905".... 687.569

T. 20 N., R. 9 E., northwest corner sec. 6, north of road, south side of J. W. James' house, brick foundation; aluminum tablet stamped "748 ILLINOIS 1905".. 748.187

T. 20 N., R. 9 E., sec. 18, 0.5 mile south of northwest corner of; west side, north abutment bridge; aluminum tablet stamped "728 ILLINOIS 1905".. 727.746

MAHOMET QUADRANGLE.

NEAR CHAMPAIGN WEST OVER ILLINOIS CENTRAL RAILWAY TO NEAR SEYMOUR, THENCE SOUTH ALONG HIGHWAYS TO SOUTHWEST CORNER OF SEC. 7, T. 18 N., R. 7 E., THENCE EAST TO SOUTHEAST CORNER OF SEC. 12, T. 18 N., R. 8.

Staley, in front of station; top of north rail...................... 740.6

T. 19 N., R. 8 E., southwest corner sec. 9, northeast corner road; iron post stamped "734 ILLINOIS 1905"......................... 734.425

Bondville, in front of station; top of north rail.................. 716.2

Bondville, 300 feet east of station, 50 feet north of track; iron post stamped "717 ILLINOIS 1905"................................ 716.738

Seymour, in front of station; top of north rail.................... 699.0

Seymour, 100 feet west of station, north side of right of way; iron post stamped "698 ILLINOIS 1905"............................ 697.650

T. 19 N., R. 7 E., southwest corner sec. 18, north of road; iron post stamped "707 ILLINOIS 1905"................................ 707.015

T. 19 N., R. 7 E., southwest corner sec. 31, southwest corner of road; iron post stamped "708 ILLINOIS 1905"...................... 708.339

	Feet.
T. 18 N., R. 7 E., southwest corner sec. 7, northwest corner road; iron post stamped "702 ILLINOIS 1905"	702.240
T. 18 N., R. 7 E., southwest corner sec. 10, northeast angle of cross-roads, intersection; iron post stamped "692 ILLINOIS 1905"	691.892
T. 18 N., R. 7 and 8 E., southwest corner sec. 7, southwest corner of road; iron post stamped "690 ILLINOIS 1905"	690.339
T. 18 N., R. 8 E., southwest corner sec. 10, northeast corner of road, southwest corner schoolyard; iron post stamped "728 ILLINOIS 1905"	728.474

MAHOMET EAST ALONG HIGHWAY, TO SOUTHWEST CORNER SEC. 7, T. 20 N., R. 9 E.

Mahomet, 230 feet west of station; 15 feet north of track; iron post stamped " ? "	712.170
T. 20 N., R. 7 E. and 8 E., secs. 13 and 18, north of road; iron post stamped "747 ILLINOIS 1905"	747.206
T. 20 N., R. 8 E., sec. 10, southwest corner of; northeast corner of road; iron post stamped "772 ILLINOIS 1905"	772.516

Danville Quadrangle—Vermilion County.—The elevations in the following list were originally based on the elevation of the Chicago and Eastern Illinois Railroad, in front of station at Danville Junction, 613.5 feet above mean sea level. Dependent on this, the central datum tablet, placed in the post office building, is stamped "Dnvl. 603." In 1906, the bench mark at Catlin was connected by spur precise line with the precise level line run from Olney via Fairmount to Champaign, the bench mark at the latter place having been established in 1905 by the precise level line run from Pekin. As a result of the 1907 adjustment a correction of 1.027 feet has been applied to original elevations on the Danville quadrangle to reduce them to mean sea level.

Bench marks set in 1897 are stamped "Dnvl" in addition to figures of elevation.

The leveling was done in 1897 by Mr. John L. McCalman, levelman. The work was done prior to coöperation.

DANVILLE QUADRANGLE.

Danville Junction, in front of station, railroad crossing; top of rail	612.4
Danville, in front of Chicago and Eastern Illinois R. R. station; top of rail	597.1
Danville, in front of station of Wabash Railroad; top of rail	597.7
Danville, in front of Chicago, Cleveland, Cincinnati and St. Louis railroad station; top of rail	604.2
Danville, post-office building, east face of north balustrade, 1.5 feet above sidewalk; bronze tablet stamped "DNVL 603"	601.499
Danville, courthouse, just south of step to west entrance, second course above sidewalk; bronze tablet stamped "Dnvl 604"	602.769
Westville, T. 18 N., R. 11 E., sec. 5, southwest corner of; iron post stamped "DNVL 672"	671.063
T. 19 N., R. 11 W., sec. 27, in north half of; floor of bridge over Vermilion River on Grape Creek road	532.4
Catlin, T. 19 N., R. 12 W., sec. 34, near center of; iron post stamped "DNVL 658"	657.396
T. 20 N., R. 10 W., sec. 18, quarter corner east side of, on State line; iron post stamped "DNVL 720"	718.917
T. 20 N., R. 11 W., sec. 11, northeast corner of; rock at section corner	698.2

	Feet.
T. 20 N., R. 11 W., sec. 17, quarter corner north side of; iron post stamped "DNVL 655"	654.084
T. 2_ N., R. 12 W., sec. 35, southwest corner of; iron post stamped "DNVL 649"	648.033

Havana, Petersburg, Saidora, Springfield and Tallula Quadrangles—Mason, Menard and Sangamon Counties.—The elevations in the following list depend on a bench mark established by U. S. Army Engineers at Havana, Illinois, at south end of east pier of highway bridge over Illinois river, three feet from west side, top of copper bolt; its value corrected to 1907 adjustment being 451.360 feet. A double rodded line was run over the Chicago, Peoria and St. Louis Railroad to Athens; the balance of the leveling was run in circuits with a single rod.

The leveling on the double rodded line and most of the leveling on Springfield quadrangle was done in 1905 by Mr. R. C. Howard. Most of the leveling on the Tallula quadrangle and part on Springfield quadrangle was done in 1906 by Henry Bücher, levelman.

The work was done in coöperation with the State and the standard bench marks are stamped with the State name.

HAVANA QUADRANGLE.

AT HAVANA.

	Feet.
Havana, Army Engineers bench mark, iron highway bridge over Illinois River, on top of south end of east pier, top of copper bolt 3 feet from west side of pier	451.360

SAIDORA QUADRANGLE.

HAVANA SOUTH ALONG THE CHICAGO, PEORIA AND ST. LOUIS RAILROAD TO KILBOURNE.

(Double Rodded Line.)

Long Branch, 255 feet south of engine room of grain elevator, in west wall, 5.4 feet north of south wall, 4.6 feet south of north wall, 5.5 feet above ground; aluminum tablet stamped "498 ADJ 1905"	491.281
Kilbourne, in front of station, main line; top of east rail	494.
Kilbourne, McFaddens Elevator, in north side of northwest foundation pillar; aluminum tablet stamped "502 ADJ 1905"	495.565

PETERSBURG QUADRANGLE.

KILBOURNE SOUTHEAST ALONG CHICAGO, PEORIA AND ST. LOUIS RAILROAD TO PETERSBURG.

(Double Rodded Line.)

Oakford, C. Lutz's store, in west wall brick foundation, 2 feet from southwest corner; aluminum tablet stamped "502 ADJ 1905"	495.159
Atterbury, W. C. Koppleens grain elevator, northwest corner of, rock foundation; aluminum tablet stamped "609 ADJ 1905"	601.764
Hilltop, top of east rail of main line in front of station	603.
Petersburg, in front of station; top of east rail	505.5
Petersburg, Menard County courthouse, north wall, 2 feet east of entrance, 4 feet above ground; aluminum tablet stamped "524 ADJ 1905"	523.706

TALLULA QUADRANGLE.

PETERSBURG SOUTHEAST ALONG CHICAGO, PEORIA AND ST. LOUIS RAILROAD TO ATHENS.

(Double Rodded Line.) Feet.

Tice schoolhouse, west side, brick foundation, 12 feet east of, north side; aluminum tablet stamped "610 ADJ 1905".................. 610.511
Tice, in front of station; top of rail.......................... 616.

PETERSBURG SOUTHWEST ALONG CHICAGO AND ALTON RAILROAD TO POINT 0.8 MILE SOHTHWEST OF TALLULA, THENCE SOUTH ALONG HIGHWAYS TO ROAD CROSSING 1.5 MILES WEST OF PLEASANT PLAINS, THENCE EAST ALONG BALTIMORE AND OHIO SOUTHWESTERN RAILROAD TO SPRINGFIELD.

T. 18 N., R. 7 W., sec. 28, center of, 0.7 mile southwest of north and south road crossing, southwest corner of stone culvert, square cut in top of (Railroad bench mark)............................ 605.416
Tallula, 2.8 miles northeast of, T. 18 N., R. 7 W., sec. 33, near northwest corner of, 350 feet southwest of road crossing from east to west, in northwest wall of stone culvert, in coping stone, 10 feet northeast of southwest corner; aluminum tablet stamped "587 ADJ 1905".. 586.759
Tallula, 0.9 mile northeast of, 320 feet northeast of milepost "Chicago 194," northwest wall of stone culvert, in first course of masonry below coping; aluminum tablet stamped "596 ADJ 1905". 595.554
Tallula, 0.8 mile southwest of, T. 17 N., R. 8 W., sec. 12, 0.25 mile south of center, 350 feet northeast of point where wagon road turns south from railroad, in top of southeast wall of stone culvert, 6.5 feet southwest of northeast corner; aluminum tablet stamped "622 ADJ 1905"................................... 621.890
Pleasant Plains State Bank, water table in north front, in top of, 0.3 foot east of west end of watertable; aluminum tablet stamped "615 ADJ 1905".. 615.350
T. 16 N., R. 7 W., sec. 14, southeast quarter of, 1.9 mile east of Pleasant Plains, 520 feet east of north and south road crossing, at bottom of fill, stone culvert, in top of south wall at southwest corner of; aluminum tablet stamped "591 ADJ 1905"............. 591.067
Richland, T. 16 N., R. 7 W., sec. 11, in southeast quarter of, in south wall of brick gasoline storage house of the Richland Farmers Elevator Co., 1.5 feet east of southwest corner and 2.2 feet above ground; aluminum tablet stamped "612 ADJ 1905".............. 611.752
T. 17 N., R. 8 W., sec. 36, north quarter corner of, northwest corner of crossroads, on west side of road, 1 foot east of fence and 23 feet north of fence corner at southwest corner of Bethel Church Cemetery; iron post stamped "615 ADJ 1905"....................... 615.358
Farmingdale, 1.2 miles west of, west of bridge over wagon road, T. 16 N., R. 7 W., sec. 24, road north and south is just south of northeast corner of section, iron bridge No. 226, east abutment, in top of north wall, 15 feet west of east end of; aluminum tablet stamped "573 ADJ 1905"..................................... 573.089
Bradfordton, 1.1 miles west of, north and south road crossing of railroad, at northwest corner of crossing, 1.7 feet east of fence and 40 feet north of track; iron post stamped "601 ADJ 1905".... 601.470

ROAD CROSSING OF BALTIMORE AND OHIO SOUTHWESTERN RAILROAD 1.5 MILES WEST OF PLEASANT PLAINS ALONG HIGHWAYS SOUTH TO BERLIN, THENCE EAST AND NORTH TO FARMINGDALE.

T. 16 N., R. 8 W., sec. 1, south quarter corner of, T road to west, at southwest corner of junction on south side of road 1.3 feet north of fence, and 18 feet west of east line of fence; iron post stamped "618 ADJ 1905".. 618.249

	Feet.
T. 16 N., R. 8 W., sec. 25, northeast corner of, quarter mile west of, T road to south, on north side of road 1 foot south of fence and east of north and south fence running north opposite center of junction of roads; iron post stamped "630 ADJ 1905"	629.882
T. 15 N., R. 8 W., sec. 1, northeast corner, 0.25 mile west of, on west side of road at northwest corner of jog in road, 1 foot east of fence, 60 feet north of south fence line; iron post stamped "609 ADJ 1905"	609.327
T. 15 N., R. 7 W., sec. 8, near center of, Old Berlin, Old Berlin schoolhouse, west wall, in brick foundation, 1.1 foot north of southwest corner and 0.5 foot below frame structure; aluminum tablet stamped "640 ADJ 1905"	640.158
T. 16 N., R. 7 W., sec. 33, southeast corner, 0.25 mile west of, T road to east, on west side of road, 410 feet north of iron bridge just south of junction of roads, 20 feet north of fence along north side of house lawn and 1.4 feet east of fence; iron post stamped "587 ADJ 1905"	586.981
T. 15 N., R. 7 W., sec. 1, northwest corner, 0.25 mile east of, junction of north and south road and private road to west, on west side of road 2 feet east of old fence, 2.6 feet south of telegraph pole and 45 feet north of stone in road marking town line; iron post stamped "609 ADJ 1905"	609.134
T. 15 N., R. 6 W., sec. 6, northeast corner, 0.25 mile south of, at northeast corner of crossroads, on north side of road, 1.4 feet south of fence and 11 feet east of fence corner; iron post stamped "610 ADJ 1905"	610.455
T. 16 N., R. 6 W., sec. 19, east quarter corner of, T road west, at northwest corner of junction of roads, on west side of road, 1.4 feet east of fence and 26 feet north of south line of fence; iron post stamped "598 ADJ 1905"	597.747
FARMINGDALE ALONG HIGHWAY NORTH 10 MILES, THENCE NORTHEAST TO ATHENS.	
T. 16 N., R. 6 W., sec. 17, in northwest quarter of, T road north, on south side of east and west road opposite junction, 1.5 feet north of fence and 2.5 feet east of fence corner; iron post stamped "589 ADJ 1905"	589.275
Salisbury schoolhouse, T. 17 N., R. 6 W., sec. 29, in southwest quarter of, in east wall of schoolhouse, 29 feet north of southeast corner, in space between stone foundation and brick upper wall; aluminum tablet stamped "592 ADJ 1905"	591.575
T. 17 N., R. 6 W., sec. 17, near center of, T road east, at northeast corner of, north side of road, 0.5 foot south of fence and 30 feet east of junction of roads; iron post stamped "597 ADJ 1905"	597.094
T. 17 N., R. 6 W., sec. 9, near northwest corner of, T road south, at southeast corner of junction, on south side of road on bank 30 feet east of center of junction; iron post stamped "573 ADJ 1905"	573.391

Springfield Quadrangle.

ATHENS SOUTHEAST AND SOUTH ALONG CHICAGO, PEORIA AND ST. LOUIS RAILWAY TO SPRINGFIELD.

Athens, City Hall, west wall, on watertable; aluminum tablet stamped "606 ADJ 1905"	605.783
Cantrall, in front of station; top of north rail	589.
Cantrall, Cantrall Coöperative Coal Company's store; in watertable, east side of building, 3 feet north of south side; aluminum tablet stamped "596 ADJ 1905"	596.181
Dunlap schoolhouse, north wall, brick foundation, 2 feet from east wall; aluminum tablet stamped "584 ADJ 1905"	583.770
Andrews, in front of station; top of west rail	583.9

	Feet.
Springfield post-office, water table, east side, 12 feet from southeast corner; aluminum tablet stamped "599 ADJ 1905"...........	598.997
Springfield, City Bench mark, southwest entrance courthouse grounds, in stone post marked "City B. M. 58.44;" top of copper bolt	598.319

SPRINGFIELD EAST AND NORTH ALONG HIGHWAY VIA RIVERTON TO WILLIAMSVILLE THENCE WEST TO CANTRALL.

T. 16 N., R. 4 W., near center sec. 21, in west wall of brick foundation to church; aluminum tablet stamped "576 ADJ 1905"........	576.450
Riverton Opera House, T. 16 N., R. 5 W., near southeast corner sec. 9, south side, southeast corner stone threshold Opera House; aluminum tablet stamped "553 ADJ 1905"	52.796
T. 17 N., R. 5 W., 0.25 mile east of, center line between secs. 32 and 33, iron highway bridge over fork of Wolf Creek, east abutment, southwest corner; aluminum tablet stamped "535 ADJ 1905".....	528.424
T. 17 N., R. 5 W., near center east half sec. 20, Locust Lane schoolhouse, west wall brick foundation; aluminum tablet stamped "578 ADJ 1905"..	578.432
T. 17 N., R. 5 W., near center sec. 4, Williamsville, east wall of Prater's Bank; aluminum tablet stamped "606 ADJ 1905".........	605.649
T. 18 N., R. 6 W., sec. 35, on south line of, north side of road, Fred Van Menner's house, in west wall of foundation; aluminum tablet stamped "591 ADJ 1905"	591.347

St. Louis Quadrangle—Madison and St. Clair Counties.—The elevations in the following list depend on the Coast and Geodetic Survey bench mark I_3, being a mark on a large bronze plate with the inscription "U. S. Coast and Geodetic Survey Bench Mark 1882," in the south face of the eastern land pier of the great bridge at East St. Louis, its accepted elevation being 413.966 feet above mean sea level as determined by latest adjustment.

The leveling was done in 1903 by Mr. L. Scott Smith, levelman.

The bench marks are stamped "St. Louis" in addition to figures of elevation.

ST. LOUIS QUADRANGLE.

EAST ST. LOUIS GREAT BRIDGE ALONG HIGHWAY TO EDGEMONT, THENCE NORTH TO MOLIENBOCK, THENCE WEST TO GRANITE CITY.

	Feet.
East St. Louis, a mark on large bronze plate on east land pier of "Great Bridge," inscribed "U. S. Coast and Geodetic Survey B. M. 182—I_3	413.966
Caseyville, 0.25 mile east of, north end west abutment railroad bridge; aluminum tablet stamped "449 ST. LOUIS"	449.160
Molienbock, Horseshoe Lake, northeast end of bayou, southeast abutment iron bridge over; aluminum tablet stamped "415 ST. LOUIS"	414.795
Granite City, northwest face, northeast wing public schoolhouse, top of stone foundation; aluminum tablet stamped "431 ST. LOUIS".	430.978
Granite City, signal tower opposite Union Station, southwest corner of foundation (standard city B. M.)	425.888

EDGEMONT SOUTH ALONG HIGHWAY TO OGLES, THENCE WEST TO SCHNAFF HOUSE.

(Single Spur Line.)

	Feet.
Ogles, 100 yards north of west bound track of Illinois Central Railroad, on east side of road, south foundation of large brick house; aluminum tablet stamped "576 ST. LOUIS"	576.129
T. 1 N., R. 9 W., sec. 17, 0.25 mile west of center of, 1.2 miles northeast of Imbs, in northwest corner of foundation of John Schnaff's house; aluminum tablet stamped "517 ST. LOUIS"	517.085

Belleville and Breese Quadrangles—Bond, Madison and St. Clair Counties.—The elevations in the following list depend on an aluminum tablet set in 1903 in west abutment of Baltimore and Ohio railroad bridge 0.25 mile east of Caseyville, stamped "449," the elevation of which is accepted as 449.160 feet.

All bench marks are stamped "ADJ" in addition to the figures of elevation.

The leveling on the Belleville quadrangle was done by Mr. C. S. Blair, levelman, and of the Breese quadrangle by Mr. C. F. Wood, levelman, both in 1905.

BELLEVILLE QUADRANGLE.

NEAR CASEYVILLE VIA BALTIMORE AND OHIO RAILROAD TO RIDGE PRAIRIE THENCE ALONG HIGHWAYS SOUTH TO BELLEVILLE, EAST TO 4 MILES EAST OF GRASSLAND, NORTH TO SUMMERFIELD AND WEST ALONG BALTIMORE AND OHIO RAILROAD TO RIDGE PRAIRIE.

	Feet.
Ridge Prairie, at southwest corner of road crossing; 0.25 mile east of Furmans, 20 feet south of track, iron post stamped "564 ADJ".	563.164
Belleville, northeast corner of courthouse yard, iron post stamped "Prim. Trav. Sta. No. 15, ADJ 531"	530.682
Grassland, 100 feet east of, 200 feet south of station; iron post stamped "Prim. Trav. Sta. No. 16, 435 ADJ"	434.306
Grassland, 4 miles east of; northeast corner of road crossing, southwest corner of field of J. B. Ereeze, iron post stamped "Prim. Trav. Sta. No. 17, 469 ADJ"	468.778
Summerfield, schoolhouse, southeast corner of; aluminum tablet stamped "Prim. Trav. Sta. No. 18, 478 ADJ"	478.074
Lebanon, stone step, just west of main entrance to St. Joseph's church, aluminum tablet stamped "467 ADJ"	466.296
O'Fallon, southwest corner of brick platform, at B. & O. station; iron post stamped "551 ADJ"	550.520

NEAR CASEYVILLE VIA VANDALIA RAILROAD TO ST. JACOBS, THENCE SOUTH ALONG HIGHWAYS TO SUMMERVILLE.

Collinsville, at northwest corner of road crossing; just west of station; opposite saloon of Schmacker Bros., iron post stamped "474 ADJ"	472.974
Formosa, northeast corner of stone platform, iron post stamped "571 ADJ"	570.155
Troy, 100 feet north of northwest corner of station; iron post stamped "549 ADJ"	548.626
St. Jacobs, 0.25 mile west of; south side of stone bridge, aluminum tablet stamped "506 ADJ"	504.883
Summerfield, 3.5 miles north of; at southwest corner of junction, 30 feet west of cottonwood, iron post stamped "507 ADJ"	506.257

Breese Quadrangle.

FOUR MILES EAST OF GRASSLAND EAST ALONG HIGHWAYS TO GERMANTOWN AND NORTH TO BREESE, THENCE WEST ALONG BALTIMORE AND OHIO RAILROAD TO SUMMERFIELD.

	Feet.
New Baden, in bank building, aluminum tablet stamped "463 ADJ"	462.069
Albers, in Louis Foytman's house, second one north of railroad, west side of street, aluminum tablet stamped "445 ADJ"	444.477
Germantown, Boniface's school, in northeast corner, aluminum tablet stamped "433 ADJ"	432.236
Breese, in northwest corner of St. Dominic school building, tablet stamped "458 ADJ"	458.120
Aviston, east side of entrance, south side of brick catholic church, tablet stamped "475 ADJ"	474.385
Trenton, in southeast corner of city hall, tablet stamped "498 ADJ".	497.606

ST. JACOBS VIA VANDALIA LINE TO HIGHLAND, THENCE EAST AND SOUTH ALONG HIGHWAYS VIA SEBASTOPOL TO BREESE.

Highland, in First National Bank of Highland, aluminum tablet stamped "545 ADJ"	544.680
Sebastopol, in south side of old brick building, aluminum tablet stamped "545 ADJ"	545.325
St. Rose, in north side of catholic church, in door sill, aluminum tablet stamped "504 ADJ"	503.977
Breese, 3.5 miles north of; in east side of house of August Lager, aluminum tablet stamped "473 ADJ"	472.934

Baldwin, Carlyle, Centralia, Chester, New Athens, Okawville and Sparta Quadrangle—Clinton, Monroe, St. Clair and Washington Counties.—The elevations in the following list are based upon the 1903 adjustment. No Coast and Geodetic Survey bench marks were recovered on Carlyle quadrangle.

The leveling was done in 1907 by Mr. W. A. Gelbach, levelman. The leveling on the Chester quadrangle and part of Baldwin quadrangle was done by Mr. P. E. Fletcher, Resident Engineer, under the direction of Dr. H. Foster Bain, Director of the State Geological Survey, the other work was done in coöperation and the standard bench marks are all stamped with the State name.

Okawville Quadrangle.

BARTELSO SOUTH TO COVINGTON, THENCE SOUTHWEST ALONG HIGHWAYS TO OKAWVILLE, THENCE WEST ALONG LOUISVILLE AND NASHVILLE RAILROAD TO MASCOUTAH.

	Feet.
Okawville, 3 miles east of, 0.5 mile west of Frogtown, southwest corner of crossroads; iron post stamped "448 1907"	448.427
Okawville, southwest corner of schoolyard; iron post stamped "445"	444.681
Venedy, 50 feet south of station by picket fence; iron post stamped "410 1907"	410.508
New Memphis, railroad crossing west of station, south of track and west of wagon road; iron post stamped "409"	409.492
New Memphis, 3 miles west of station, 250 feet north of railroad at crossroads, southwest corner of crossroads; iron post stamped "424"	425.395

VENEDY STATION SOUTHWEST ALONG HIGHWAYS TO POINT 2 MILES EAST OF MARISSA.

	Feet.
Venedy, north end of town, on road leading to Venedy station, southwest corner of T road west; iron post stamped "428 1907"	426.945
T. 2 S., R. 5 W., secs. 6 and 7, 0.25 mile north of quarter corner between, southwest corner of crossroads; iron post stamped "424 1907"	423.063
St. Libory, 1 mile east of, junction of four roads, south side of road leading east; iron post stamped "430 1907"	428.889
St. Libory, 1 mile south and 0.5 mile east of, southwest corner of crossroads; iron post stamped "432 1907"	431.671
Darmstadt, 1 mile south by 0.5 mile east of, southwest corner of T road south; iron post stamped "432 1907"	431.240
Oak Grove Saloon, 150 feet south of, west side of road; iron post stamped "448 1907"	447.715

ST. LIBORY WEST TO FAYETTEVILLE.

Fayetteville, 2.5 miles east of, southeast corner of schoolhouse, in brick foundation; aluminum tablet stamped "Prim. Trav. Sta. No. 19, 1907 ILLINOIS 410"	409.995

NEW ATHENS QUADRANGLE.

MASCOUTAH WEST ALONG LOUISVILLE AND NASHVILLE RAILROAD TO BELLEVILLE.

Mascoutah, railway crossing, 0.25 mile east of station, west side of street 4 feet north of railroad right of way; iron post stamped "424 1907"	424.619
Rentchlers, 0.25 miles east of station, 40 feet north of track, east of wagon road; iron post stamped "458 1907"	458.052
Rentchlers, 2 miles west of, railway crossing by brick schoolhouse, north part of schoolyard, 30 feet from corner of yard, 2 feet from right of way fence; iron post stamped "464 1907"	464.427

MASCOUTAH SOUTH ALONG HIGHWAY TO FAYETTEVILLE.

Mascoutah, 3 miles south of, southeast corner of schoolyard of "Crossroads School;" iron post stamped "442 1907"	442.129
Fayetteville, 1 mile north from, north and west sides of road at road fork; iron post stamped "417 1907"	417.271

FAYETTEVILLE WEST VIA FIVE FORKS TO NEAR SMITHTON, THENCE NORTHERLY TO BELLEVILLE.

Fayetteville, 1.25 miles west of, south and east sides of road at road fork south; iron post stamped "412 1907"	412.339
T. 2 S., R. 7 W., corner secs. 10, 11, 14, 15, southwest corner of T road west; iron post stamped "405 1907"	404.887
New Athens, 3.5 miles northwest of, "Five Forks," southeast corner of schoolyard; iron post stamped "446 1907"	446.165
T. 2 S., R. 8 W., corner secs. 11, 12, 13 and 14, northwest corner of crossroads; iron post stamped "440 1907"	440.000
Smithton, 2 miles south of, northeast corner of T road east; iron post stamped "Prim. Trav. Sta. No. 22, 1907 ILLINOIS 467 1907"	466.383
Smithton, 1.5 miles east of, east side of road at T road west at junction of 4 roads; iron post stamped "431 1907"	431.213

Feet.

Freeburg, 1.5 miles west of, T. 1 S., R. 7 W., middle sec. 24, north east corner of T road north; iron post stamped "513 1907" 512.515

Freeburg, 1.5 miles west by 3 miles north of, northwest corner of schoolyard of brick school on Freeburg-Belleville plank road; iron post stamped "483 1907" 482.209

FIVE FORKS SOUTH VIA NEW ATHENS TO FOUR CORNERS, THENCE SOUTHEAST TO MIDDLE OF SECTION 22, T. 3 S., R. 7 W.

New Athens, northwest corner of schoolyard; iron post stamped "430 1907" 429.865

T. 3 S., R. 7 W., quarter corner between secs. 4 and 5, 0.25 mile east of, north side of road at T road south; iron post stamped "415 1907" 414.678

T. 3 S., R. 7 W., quarter corner between secs. 16 and 17, 0.25 mile east of, southwest corner of crossroads; iron post stamped "414 1907" 414.040

T. 3 S., R. 7 W., middle sec. 22, southeast corner of crossroads; iron post stamped "Prim. Trav. Sta. No. 20, 1907 ILLINOIS 1907". 406.160

FROM FOUR CORNERS 4 MILES SOUTH OF NEW ATHENS TO POINT 2 MILES NORTH OF REDBUD.

T. 3 S., R. 8 W., quarter corner between secs. 23 and 26, 0.25 mile north of, northeast corner of crossroads; iron post stamped "391 1907" 390.762

FROM POINT 2 MILES NORTH OF REDBUD ALONG HIGHWAYS NORTH TO BELLEVILLE.

T. 3 S., R. 8 W., quarter corner between secs. 9 and 10, 0.25 mile east of, northwest corner of T road north; iron post stamped "438 1907" 438.162

New Athens, 4 miles due west of, near center of Spanish Survey No. 607, southwest corner of schoolyard "Klein school;" iron post stamped "429 1907" 428.839

Chester Quadrangle.

CHESTER NORTH ALONG ILLINOIS SOUTHERN RAILROAD TO MISSOURI JUNCTION.

32 Kaskaskia, 1.75 miles below town of, on west side of Kaskaskia and Chester road, at foot of bluffs, just inside of field of J. Watier, being a Miss. Riv. Comm. bench mark; top of iron post 392.83

(The correction applied here to reduce from Memphis datum was 6.85 ft.)

Kerley's Lake, northwest corner of station platform, near south end of Edgar's Mill creek trestle, in top of concrete post; aluminum tablet stamped ' ? " 385.113

Missouri Junction, at turn of Missouri Junction and Ellis creek road, 900 feet northeast of station; in top of concrete post; aluminum tablet stamped " ? " 407.467

Baldwin Quadrangle.

MISSOURI JUNCTION ALONG ILLINOIS SOUTHERN RAILROAD TO POINT 2 MILES EAST OF EVANSVILLE THENCE NORTH ALONG HIGHWAYS TO POINT MIDDLE OF SECTION 22, T. 3 S., R. 7 W.

Nine Mile Creek bridge of Illinois Southern R. R., on west end of north abutment; plate 383.809

Evansville, 50 feet south of west station platform at east side of road, in top of concrete post; aluminum tablet stamped " ? " 414.375

	Feet.
T. 5 S., R. 7 W., sec. 8, quarter corner south side of, northeast corner of crossroads, in top of concrete post; aluminum tablet stamped " ? "	450.069
T. 4 S., R. 7 W., sec. 28, southwest quarter of, at junction of Evansville-Baldwin, and Baldwin-Preston roads, in top of concrete post; aluminum tablet stamped " ? "	454.822
T. 4 S., R. 7 W., sec. 3, quarter corner east side of, in top of concrete post; aluminum tablet stamped " ? "	429.264
T. 3 S., R. 7 W., sec. 27, at center of, in top of concrete post; aluminum tablet stamped " ? "	409.150

AT POINT 2 MILES NORTH OF RED BUD.

Red Bud, 2 miles north of, T. 3 S., R. 8 W., quarter corner between secs. 28 and 29, northwest corner of crossroads; iron post stamped "Prim. Trav. Sta. No. 21, 1907 ILLINOIS 447, 1907"	446.473

MARISSA WEST TO MIDDLE OF SECTION 22, T. 3 S., R. 7 W.

T. 3 S., R. 6 and 7 W., corner secs. 19, 24, 25 and 30, 0.25 mile west of, 3.5 miles west of Marissa, southeast corner of crossroads; iron post stamped "411, 1907"	410.940
Marissa, southwest corner of schoolyard; iron post stamped "449, 1907"	448.378

Sparta Quadrangle.

MARISSA EAST 2 MILES TO SOUTHWEST CORNER SEC. 24, T. 3 S., R. 6 W.

T. 3 S., R. 6 W., corner secs. 23, 24, 25 and 26, 2 miles east of Marissa, northeast corner of crossroads; iron post stamped "Prim. Trav. Sta. No. 18, 1907 ILLINOIS 433, 1907"	432.942

Carlyle Quadrangle.

BREESE EAST ALONG BALTIMORE AND OHIO SOUTHWESTERN RAILROAD TO HUEY, THENCE SOUTH ALONG HIGHWAYS TO HOFFMAN, THENCE WEST ALONG SOUTHERN RAILWAY TO BARTELSO, THENCE NORTH ALONG HIGHWAY TO BECKEMEYER.

Beckemeyer, railway crossing at west end of town, 50 feet north of track, by roadside; iron post stamped "451"	451.287
Carlyle, southeast corner of courtyard; iron post stamped "461"	460.787
Huey, railway crossing at east end of station, south of track, on east side of wagon road, 4 feet south of corner fence post; iron post stamped "454"	453.861
Hoffman, 1.75 miles north of, north side of road at fork, 8 feet east of corner fence post; iron post stamped "Prim. Trav. Sta. No. 4, 1907; 454"	453.582
Hoffman, 200 feet east of railway station, 50 feet north of tracks, iron post stamped "Prim. Trav. Sta. No. 3, 1907; 456"	456.185
Posey, 0.5 mile east of station, 40 feet north of track and east of wagon road; iron post stamped "451"	450.544
Zachary Siding, 0.25 mile east of, 60 feet north of tracks, 20 feet west of wagon road; iron post stamped "418"	417.504
Bartelso, 60 feet south of tracks and 150 feet east of station, corner of lot by H. F. Johnson's saloon, 2 ft. inside of sidewalk; iron post stamped "450"	449.572
Beckemeyer, 2.75 miles south of, at crossroads, north and east sides of roads respectively, 3 feet east of corner fencepost; iron post stamped "459"	459.300

HUEY ALONG HIGHWAYS TO POINT 7.5 MILES NORTHEAST OF HUEY.

	Feet.
Huey, 2 miles north by 1 mile east of, "White School House," southeast corner of schoolyard; iron post stamped "463"	462.043

BECKEMEYER NORTHWEST VIA FROGTOWN TO ST. ROSE.

Frogtown, road fork, north and west sides of roads respectively; iron post stamped "455"	454.872

KEYESPORT WEST AND SOUTHWEST ALONG HIGHWAYS TO FROGTOWN.

Keyesport, east railway crossing just south of station, south side of high bank; iron post stamped "453"	453.147
Keyesport, 1 mile west from, south and west sides of roads respectively; iron post stamped "473"	473.081
Keyesport, 5 miles west of, intersection of Clinton-Bond County line, and Carlyle-Greenville road, north and west sides of roads respectively; iron post stamped "Prim. Trav. Sta. No. 7, 1907, 512"	512.456
Keyesport, 8 miles west of, crossroads, Bond-Clinton County line, south and east sides of roads respectively; iron post stamped "Prim. Trav. Sta. No. 8, 1907 473"	473.008
Jamestown, 2.5 miles east of, Bond-Clinton County line, road fork, north side of county road; iron post stamped "Prim. Trav. Sta. No. 9, 1907 480"	480.023
Frogtown, 3.5 miles north and 1 mile east of, road fork, 0.5 mile west of catholic church, south side of road; iron post stamped "467"	467.610
Frogtown, 2 miles north of, road forks, west side of road; iron post stamped "463"	463.238

Centralia Quadrangle.

POINT 7.5 MILES NORTHEAST OF HUEY NORTHERLY TO KEYESPORT THEN TO BOULDER.

Boulder, 2.25 miles south by 0.5 mile west of, northwest corner of schoolyard; iron post stamped "470"	470.398
Boulder, 1.5 miles northwest of, east side of railroad at crossing, north side of wagon road; iron post stamped "442"	442.459

Hardinville, Merom, Olney and Russellville Quadrangles—Crawford, Jasper, Lawrence and Richland Counties.—The elevations in the following list are based upon bench mark B_3 of the Coast and Geodetic Survey at Olney, Illinois, a square cut at the base of one of the columns of the north face of the court house. The elevation now accepted is 486.117 feet above mean sea level as determined by the 1907 adjustment.

The leveling was done in 1907 by Mr. Henry Bücher, levelman.

The work was done in coöperation with the State and the bench marks are stamped with the State name.

Olney Quadrangle.

OLNEY EAST 4 MILES ALONG BALTIMORE AND OHIO SOUTHWESTERN RAILROAD.

(Mean of Direct and Reverse Leveling.)

B_3 Olney, Richland County Courthouse, cut at the base of one of the columns of north face of; lettered "B_3 B[]M USC&GS 1882"	486.117

No. III, Olney, near the southeast corner of grounds of public school, on the monument marking the U. S. Engineers Base Line; the top of the monument bears the inscription "U. S.," and the bench mark is the center of the space inclosed by the lower curve of the S. Feet.

NOTE: This monument is loose on its foundation; it rocks. (1907 adjustment Coast and Geodetic Survey elevation 480.376) 480.395

Olney, in front of station; top of rail 473.48

Olney, 2.70 miles east of, 1200 feet east of road crossing, in coping stone at southeast corner of south wall of stone culvert, 1.1 feet west of east end and 0.8 foot north of south end; aluminum tablet stamped "495 ADJ" 496.114

Hardinville Quadrangle.

HICKORY POINT SCHOOL ALONG HIGHWAYS NORTH, TO T. 6 N., R. 14 W., NORTHEAST CORNER SECTION 10, THENCE EAST, TO T. 6 N., R. 12 W., NORTHEAST CORNER SECTION 7, THENCE NORTH, TO INDIANAPOLIS SOUTHERN RAILROAD AND EAST ALONG LATTER 2 MILES, TO ROBINSON.

T. 4 N., R. 14 W., 0.25 mile south of northwest corner of section 27, southeast corner of T road, on east side of road, 1.3 feet west of fence, 15 feet south of fence corner; iron post stamped "510 ADJ" 510.502

T. 4 N., R. 14 W., southwest corner of section 3, northeast corner of crossroads, east side of road, 1.1 feet west of fence, 11 feet north of fence corner; iron post stamped "508 ADJ" 509.121

T. 5 N., R. 14 W., northeast corner of section 34, at southwest corner of crossroads, on west side of road, 1.1 feet east of fence, 7 feet south of fence corner; iron post stamped "496 ADJ" 496.574

T. 5 N., R. 14 W., southwest corner of section 15, northeast corner of crossroads, on north side of road near old rail fence, about 14 feet east of north and south fence line, on east side of north and south road (New Light Christian church (?) is at southeast corner of crossroads); iron post stamped "457 ADJ" 457.555

T. 5 N., R. 14 W., southeast corner of section 3, northwest corner of crossroads, west side of road, 6 feet east of fence and 4 feet north of fence corner; iron post stamped "462 ADJ" 463.263

T. 6 N., R. 14 W., northeast corner of section 27, southwest corner of crossroads, west side of road, 1.2 feet east of fence, 5.6 feet south of fence corner; iron post stamped "483 ADJ" 483.969

T. 6 N., R. 14 W., 0.25 mile east of southwest corner of section 2, T road (the branch to west is very dim), outside of road at T, 1.3 feet south of fence, 15 feet east of north and south fence at fence corner (north of center of T); iron post stamped "478 ADJ" 478.367

T. 6 N., R. 13 W., northeast corner of section 7, at southwest corner of T road, on west side of road, 1.2 feet east of fence, 7.5 feet south of fence corner; iron post stamped "483 ADJ" 483.298

T. 6 N., R. 13 W., southwest corner of section 2, (crossroads) 0.75 mile south of Stoy, on small bank by pipe line, 1 foot east of fence, 76 feet north of east and west fence line on north side of east and west road; iron post stamped "475 ADJ" 476.261

T. 6 N., R. 12 W., northeast corner of section 7, T road, on south side of road opposite the Wilson Schoolhouse, 0.7 foot north of fence, 12 feet east of fence corner, on edge of lane to south; iron post stamped "581 ADJ" 531.481

FROM POINT 0.75 MILE SOUTH OF STOY SOUTH ALONG HIGHWAYS TO T. 4 N., R. 13 W., NEAR SOUTHEAST CORNER OF SECTION 29.

	Feet.
T. 6 N., R. 13 W., northwest corner of section 23, T road, on bank on south side of road at T, 1.5 feet north of fence, 34.5 feet east of north and south section line fence; iron post stamped "484 ADJ"	485.269
Hardinville, section 34, T. 6 N., R. 13 W., on east side of main north and south road just north of Christian church, 500 feet south of crossroads, 4.2 feet north of fence line between McCarty (south side) and Newman (north side), 6.8 feet west of an old fence line north in correct position; iron post stamped "510 ADJ"	510.903
T. 5 N., R. 13 W., 0.25 mile north of southwest corner of section 4, southeast corner of T road, at T, on south side of road, 0.9 feet north of fence, 39 feet east of north and south fence line, on east side of north and south road; iron post stamped "463 ADJ"	463.826
Chauncey, southwest corner of section 28, T. 5 N., R. 13 W., at northeast corner of crossroads, on east side of road, 1.2 feet west of fence, 6.6 feet north of fence corner; iron post stamped "488 ADJ"	488.708
T. 4 N., R. 13 W., 0.25 mile north of southeast corner of section 8, northwest corner of T road, north side of road between 2 walnut trees, 1.2 feet south of fence, 28 feet west of north and south fence line on west side of north and south road; iron post stamped "492 ADJ"	492.990

FROM T. 6 N., R. 12 W., NORTHEAST CORNER OF SECTION 29, ALONG HIGHWAYS SOUTH, TO FAIRVIEW CHURCH.

T. 6 N., R. 12 W., quarter corner east side of section 29, T road at southwest corner, on south side of road, 1.1 feet north of fence 7 feet west of 2-foot oak tree at fence corner; iron post stamped "512 ADJ"	512.750
T. 5 N., R. 12 W., northwest corner of section 9, at southeast corner of crossroads, on east side of road, 0.8 foot west of fence, 6 feet south of fence corner; iron post stamped "523 ADJ"	523.318
T. 5 N., R. 12 W., 0.25 mile east of northwest corner of section 28, southeast corner of crossroads, 0.8 foot west of fence, 6 feet south of fence corner; iron post stamped "442 ADJ"	442.767
Westfort, section 32, T. 5 N., R. 12 W., iron truss bridge over Embarrass river at southwest corner, in highest part of masonry support, 1.1 feet from east edge, 0.3 feet from south edge; aluminum tablet stamped "437 ADJ"	437.339
T. 4 N., R. 12 W., northeast corner of section 18, southwest corner of crossroads, south side of road, 1.3 feet north of fence, 22 feet west of north and south fence line on west side of north and south road; iron post stamped "436 ADJ"	436.534
T. 4 N., R. 12 W., northwest corner of section 29, at crossroads, on south side of road at T, 2.1 feet north of fence line, 23 feet east of north and south fence line at fence corner; iron post stamped "455 ADJ"	455.678

MEROM QUADRANGLE.

AT ROBINSON.

Robinson, at east edge of station; top of rail	536.7
Robinson, on south side of courthouse, on west side of concrete walk, in top of concrete post at edge of wall; aluminum tablet stamped "Prim. Trav. Sta. No. 13, 534 ADJ"	534.529

Russellville Quadrangle.

ROBINSON SOUTH ALONG HIGHWAY, TO T. 6N., R. 12 W., NORTHEAST CORNER OF SECTION 29.

	Feet.
T. 6 N., R. 12 W., center of northeast quarter of section 16, cross-roads, at south east corner, on east side of road, 0.8 feet west of fence, 3.9 feet south of fence corner; iron post stamped "533 ADJ"	533.542

Bridgeport, Carmi and Mt. Carmel Quadrangles—Edwards, Lawrence, Richland, Wabash and White Counties.—The elevations in the following list are based upon the 1907 adjustment. The work on Mt. Carmel quadrangle was extended originally from adjoining work in Indiana, via Grayville, but the elevations are now corrected to agree with leveling of 1908 upon Bridgeport quadrangle based upon the 1907 Coast and Geodetic Survey adjustment, elevation of a bench mark at Olney, which is 0.785 foot greater than by 1903 adjustment, and an adjustment has been made through Carmi quadrangle to accord with elevations brought by precise leveling of 1906 from Duquoin, Illinois, corrected to agree with the 1907 adjustment at that point, which is 0.336 foot greater than by the 1903 adjustment.

The leveling was done as follows: On Mt. Carmel quadrangle mostly in 1902 by H. G. Lowe, on Bridgeport and Carmi quadrangles mostly and on Mt. Carmel quadrangle partially, in 1908 by W. A. Gelbach; on Bridgeport also, in 1907, by H. Bücher, and on Carmi also, in 1905, by C. S. Blair.

The work done in 1905 and later years was in coöperation with the State and the standard bench marks established since 1905 inclusive, are stamped with the State name.

Mt. Carmel Quadrangle.

GRAYVILLE NORTHEAST ALONG BIG FOUR RAILROAD, VIA COWLING, KEENSBURG AND SCHRODTS STATION, TO MT. CARMEL.

	Feet.
Grayville, at milepost E 32, at northwest corner of bridge 289; head of bolt	386.36
Grayville, 100 feet south of station, 6 feet east of track; iron post stamped "392 VIN"	392.113
Cowling, T. 2 S., R. 14 W., 8 inches north from northeast corner of Big Four station, 6 inches above ground; iron post stamped "397 VIN"	396.812
Keensburg, T. 2 S., R. 14 W., northwest corner of M. E. Church (frame), in face of foundation wall on north side; aluminum tablet stamped "430 VIN"	429.672
Sugar Creek (Schrodts station), T. 1 S., R. 13 W., at northeast corner of Peter Schrodts store, 1 foot north; iron post stamped "458 VIN"	458.066
Mt. Carmel Courthouse, at southwest side, in southeast wing on west sill in wall; bronze tablet stamped "465 VIN"	464.841

MT. CARMEL (junction of Big Four and Southern Railways), WEST ALONG SOUTHERN RAILWAY, VIA MAUD, TO BELMONT.

Maud, T. 1 S., R. 13 W., northeast corner of Christian Church, east side in face of foundation wall; bronze tablet stamped "442 VIN".	441.384

KEENSBURG NORTHWEST, TO BELMONT, THENCE WEST ALONG SOUTHERN RAILWAY TO BROWNS.

	Feet.
Bellmont, T. 1 S., R. 14 W., Town Hall, at southwest corner of south side in face of wall, 3 feet above ground; aluminum tablet stamped "431 VIN"	430.846
Browns, T. 1 S., R. 14 W., in southeast corner of red brick M. E. Church, in face of south wall, 3 feet above ground; aluminum tablet stamped "402 VIN"	401.728

GRAYVILLE NORTH ALONG ILLINOIS CENTRAL RAILROAD AND PUBLIC ROADS, VIA BROWNS, TO BONE GAP.

Bone Gap, T. 1 S., R. 14 W., northwest corner of Miss M. D. Rice's millinery store, north side in brick foundation; bronze tablet stamped "459 VIN"	458.746

BONE GAP ALONG PUBIC ROADS, VIA GARD'S POINT AND FRIENDSVILLE, TO PATTON, THENCE SOUTH ALONG BIG FOUR RAILROAD, TO MT. CARMEL.

Gard's Point, T. 1 S., R. 13 W., at east side of northeast corner of Lick Prairie Church; iron post stamped "434 VIN"	433.428
Patton, T. 1 S., R. 12 W., 1 foot southwest of southeast corner of frame building of J. W. Elliott, 8 inches above ground; iron post stamped "416 VIN"	416.146

A CIRCUIT RUN IN 1907 BY W. A. GELBACH CONNECTED MT. CARMEL BENCH MARK WITH PATTON AND ESTABLISHED THE FOLLOWING:

Mt. Carmel, on pier of Southern Railway bridge; zero of gage	372.05
Grand Rapids, land side of government locks at; top of coping of pier (Wabash River Survey bench mark; Engineer's elevation given being 395.913, based upon 1903 adjustment elevation at Vincennes, but the 1907 adjustment would raise it 0.663 foot which is 0.113 foot greater than the adjusted elevation here given)	396.463
T. 1 N., R. 12 W., corner of sections 20, 21, 28 and 29, in front of T road west; iron post stamped "416-1908"	416.593

CARMI QUADRANGLE.

GRAYVILLE SOUTHWEST ALONG CAIRO DIVISION OF THE BIG FOUR RAILROAD, TO NORRIS CITY.

Grayville, 100 feet south of station, 6 feet east of track; iron post stamped "VIN 392"	392.113
Carmi, 2 blocks east of station, at southwest corner opposite electric plant, in root of large tree; spike	398.28
Carmi, west side of main entrance in stone step to First Presbyterian Church; aluminum tablet stamped "399"	399.057
Brownsville, at southwest corner of stone platform; iron post stamped "417"	416.768
Stokes, in southeast corner of yard of J. Pyle's store; iron post stamped "415"	414.578

BROWNSVILLE EAST, TO MAUNIE.

Brownsville, 1.5 miles south of, at southeast corner of crossroads; iron post stamped "442—1908"	442.458
T. 6 S., R. 9 E., quarter corner between sections 9 and 10, at T road west, in center of triangular grass plot in road fork; iron post stamped "360—1908"	360.278

	Feet.
T. 5 S., R. 9 E., southwest corner of section 36, in front of T road north; iron post stamped "424—1908"	424.004
Epworth, 2 miles south of, at northeast corner of crossroads, 15 feet east of corner fence post; iron post stamped "398—1908"	398.514
Maunie, Louisville and Nashville Railway bridge over Wabash River, on coping south end of east pier, 1 foot from edge; chiseled circle (Wabash River Survey bench mark No. 32, Engineer's elevations is 370.471, based on 1903 adjustment value at Vincennes. The elevation by that line corrected to 1907 adjustment is 0.663 foot greater)	373.600
Maunie, in middle of northwest face of foundation wall to Methodist Church, 2 feet above ground; aluminum tablet stamped "375—ILLINOIS—1903"	375.417

MAUNIE NORTH, TO NEAR GRAYVILLE.

T. 5 S., R. 10 E., northeast corner of section 24, in front of T road east; iron post stamped "369—1908"	369.468
T. 5 S., R. 14 W., near corner of sections 5, 6, 7 and 8, in southwest corner of schoolyard, in front of T road west; iron post stamped "378—1908"	378.655
Phillipstown, 1 mile north of, at northeast corner of crossroads on bank; iron post stamped "498—1908"	498.359
Calvin, Union-Methodist and Baptist Church, in middle of north foundation wall about 1.5 feet above ground; aluminum tablet stamped "448—ILLINOIS—1908"	448.738
Grayville, below, Illinois Central Railway bridge over Wabash River, south end of east bank pier; U. S. E. [] B. M. (Wabash River Survey Engineer's elevation 388.590, based on 1903 adjustment from Vincennes, but corrected to 1907 adjustment datum its elevation would be 0.663 foot greater)	389.420
T. 3 S., R. 14 W., at corner of sections 29, 30, 31 and 32; on top of corner stone	402.79
T. 3 S., R. 14 W., at corner of sections 19, 20, 29 and 30, front of and 20 feet east of center line of T road south; iron post stamped "398—1908"	398.186

NEAR GRAYVILLE WEST, TO LITTLE WABASH RIVER, THENCE SOUTH, TO CARMI.

T. 3 S., R. 10 E., corner of sections 22, 23, 26 and 27, in front of T road south; iron post stamped "392—1908"	392.544
High Shoals, 0.75 mile west of bridge over Little Wabash River, in front of T road south; iron post stamped "383—1908"	383.823
T. 3 and 4 S., R. 10 E., 0.25 mile east of quarter corner between sections 32 and 5, at southeast corner of T road south, 4 feet south of corner fence post; iron post stamped "383—1908"	383.012
T. 4 S., R. 10 E., middle of section 21, at northeast corner of T road north; iron post stamped "390—1908"	390.313
T. 4 S., R. 10 E., quarter corner between sections 28 and 29, in southeast corner of school yard, at northwest corner of crossroads, in tree root; nail	387.04
Simpson Switch on Big Four Railroad, 3.25 miles northeast of Carmi, 80 feet north of track, on west side of wagon road, by wire fence; iron post stamped "388—1908"	388.749
Carmi, 0.25 mile northeast of, 400 feet east of junction of Louisville and Nashville and Big Four tracks, east of railway bridge over Little Wabash river, 6 feet high north of Big Four track, near railroad crossing, in southeast corner of bridge on railing; top of bolt head	382.27

FROM LITTLE WABASH RIVER WEST, TO BURNT PRAIRIE, THENCE SOUTH, TO BROWNSVILLE.

	Feet.
T. 3 S., R. 9 E., quarter corner between sections 23 and 24, in front of T road south, at corner of house yard; iron post stamped "386—1908"	385.991
T. 3 S., R. 9 E., quarter corner between sections 20 and 21, in front of T road south; iron post stamped "425—1908"	425.415
T. 4 S., R. 9 E., quarter corner between sections 8 and 9, at northeast corner of crossroads; iron post stamped "388—1908"	387.893
T. 4 S., R. 9 E., quarter corner between sections 29 and 32, at southwest corner of school yard, at northeast corner of T road east; iron post stamped "388—1908"	388.809
Trumbull, 0.1 mile westof, at southeast corner of crossroads, at foot of bank; iron post stamped "419—1908"	419.637

BRIDGEPORT QUADRANGLE.

FROM POINT 4 MILES EAST OF OLNEY EAST ALONG BALTIMORE AND OHIO SOUTHWESTERN RAILROAD, TO CLAREMONT, THENCE ALONG HIGHWAYS NORTH, TO HICKORY POINT SCHOOL.

(Mean of Direct and Reverse Leveling.)

Claremont station, 0.36 mile west of, south end of small artificial lake, in top of east wing of masonry dam, 0.9 foot from west edge and 1.8 feet from north edge, in northwest corner; aluminum tablet stamped "498 ADJ"	498.826
Claremont, at station crossing; top of south rail	509.8

FROM CROSSROADS 0.93 MILE NORTH OF CLAREMONT EAST ALONG HIGHWAY TO T ROAD 0.25 MILE EAST OF NORTHEAST CORNER SECTION 5, T. 3 N., R. 13 W., THENCE NORTH 1 MILE.

T. 4 N., R. 14 W., southwest corner of section 36, at northeast corner of crossroads, on east side of road, 0.7 foot west of fence, 22 feet north of fence corner; iron post stamped "509 ADJ"	510.263
T. 3 N., R. 13 W., 0.25 mile east of northwest corner of section 4, at T road, 0.7 foot north of fence, 24.5 feet east of telegraph pole, about 11 feet east of center line of north and south road; iron post stamped "483 ADJ"	484.085
T. 4 N., R. 13 W., 0.25 mile east of northwest corner of section 33, at T road, on west side of road, 2.2 feet east of fence, in concrete post flush with ground; aluminum tablet stamped "Prim. Trav. Sta. No. 10, 489 ADJ"	490.408

FROM T. 3 N., R. 13 W., SEC. 5, 0.25 MILE EAST OF NORTHEAST CORNER, EAST TO T. 4 N., R. 12 W., NORTHEAST CORNER SECTION 32, THENCE NORTH, TO FAIRVIEW CHURCH.

T. 4 N., R. 13 W., southwest corner of section 36, opposite U. B. Union Chapel, at northeast corner of crossroads, on east side of road, 1.1 feet west of fence, 62 feet north of fence; iron post stamped "570 ADJ"	571.168
T. 3 N., R. 12 W., northwest corner of section 4, at crossroads, State road east to west, on south side of road, on bank a little east of center of road to north, 0.9 foot north of fence, 18.5 feet east of telegraph pole; iron post stamped "457 ADJ"	457.461

FROM POINT 2 MILES NORTH OF BRIDGEPORT SOUTH, TO GRANT SCHOOL, THENCE WEST 5.6 MILES, THENCE NORTH, TO SUMNER.

	Feet.
Bridgeport, 100 feet north of railroad, on front face at southeast corner of yellow brick building owned by F. W. Cox, about 3 feet about sidewalk; aluminum tablet stamped "449 1908"	448.591
T. 3 N., R. 12 W., corner of sections 20, 21, 28 and 29, at northwest corner of crossroads; iron post stamped "489 1908"	489.774
Grant School, corner of sections 4, 5, 8 and 9, T. 2 N., R. 12 W., at northwest corner of crossroads, in southeast corner of school yard; iron post stamped "446 1908"	446.892
T. 2 N., R. 13 W., quarter corner between sections 4 and 9, at southwest corner of crossroads, 3 feet west of corner of John White's yard; iron post stamped "476 1908"	477.274
Sumner, on Main street, 250 feet south of railroad, at northeast corner of street crossing in brick building owned by Mart Wagner, in south face on foot from southwest corner and 3 feet above ground; aluminum tablet stamped "461 ILLINOIS 1908"	462.148
Sumner, railroad crossing on Main street; top of rail	460.5

FROM POINT 5.6 MILES WEST OF GRANT SCHOOL WEST, TO BROWNSVILLE, THENCE NORTH, TO CLAREMONT.

T. 2 N., Rs. 13 and 14 W., corner of sections 1, 6, 7 and 12, Lawrence-Richland county line, at northwest corner of crossroads, in root of tree; spike	537.90
Preston School, corner of sections 3, 4, 9 and 10, T. 2 N., R. 14 W., in front of T road east, 600 feet south of T road west, in southeast corner of school yard; iron post stamped "456 1908"	456.244
Black Oak School, corner of sections 27, 28, 33 and 34, T. 3 N., R. 14 W., at northwest corner of crossroads, in southeast corner of school yard, in tree root; spike	497.20
T. 3 N., R. 13 W., at corner of sections 21, 22, 27 and 28, at southwest corner of crossroads, by picket fence; iron post stamped "506 1908"	505.920
Claremont, in front of station; top of rail	509.7

GRANT SCHOOL SOUTH, TO NEAR PATTON.

T. 2 N., R. 12 W., quarter corner between sections 20 and 21, at northeast corner of crossroads, in southwest corner of school yard; iron post stamped "445 1908"	445.641
T. 1. N., R. 12 W., corner of sections 8, 9, 16 and 17, at northwest corner of crossroads, by picket fence; iron post stamped "462 1908"	462.325

FROM POINT 5.6 MILES WEST OF GRANT SCHOOL SOUTH AND EAST, VIA FRIENDSVILLE, TO NEAR PATTON.

T. 2 N., R. 13 W., quarter corner between sections 21 and 28, in front of T road west at schoolhouse, 4 feet south of corner fence post; iron post stamped "460 1908"	460.636
Lancaster, 400 feet east by 400 feet south of middle of section 4, T. 1 N., R. 13 W., in west face of Lutheran church directly under window south of entrance, about 2.5 feet above ground; aluminum tablet stamped "494 ILLINOIS 1908"	494.584
Stoeltz Schoolhouse, quarter corner between sections 20 and 21, T. 1 N., R. 13 W., at southwest corner of crossroads, in northeast corner of school yard; iron post stamped "459 1908"	459.431

	Feet.
Friendsville, quarter corner between sections 23 and 24, T. 1 N., R. 13 W., in east side of brick house of Dr. C. S. Couch, near southeast corner, about 3 feet above ground; bronze tablet stamped "482 VIN"	481.722

FROM STOELTZ SCHOOL WEST, TO PINHOOK, THENCE NORTH, TO BROWNSVILLE.

T. 1 N., R. 13 and 14 W., 0.25 mile north of quarter corner between sections 19 and 24, in front of and about 20 feet south of center line of T road east; iron post stamped "409 1908"	409.460
Pinhook, quarter corner between sections 21 and 22, T. 1 N., R. 14 W., at northeast corner of T road north; iron post stamped "435 1908"	435.611
T. 1 and 2 N., R. 14 W., about 0.1 mile east of quarter corner between sections 4 and 33, at northwest corner of crossroads, opposite small white house; iron post stamped "458 1908"	458.416
Red Head Schoolhouse, quarter corner between sections 16 and 21, T. 2 N., R. 14 W., at southwest corner of crossroads, in northeast corner of school yard; iron post stamped "462 1908"	462.584
Preston School, corner of sections 3, 4, 9 and 10, T. 2 R. 14 W., in front of T road east, 600 feet south of T road west, in southeast corner of school yard; iron post stamped "456 1908"	456.244

Eldorado, Enfield and New Haven Quadrangles—Gallatin, Hamilton, Saline and White Counties.—The elevations in the following list are based upon the unadjusted precise level line of 1906, DuQuoin to Shawneetown, which recovered the standard bench mark of this list at Eldorado. The elevations accepted at Duquoin, Illinois, are by precise leveling of the Coast and Geodetic Survey corrected in accord with the adjustment of 1907.

All bench marks are stamped "ADJ" in addition to the figures of elevation.

The leveling was done n 1905 by Mr. C. B. Blair, levelman.

Enfield Quadrangle.

STOKES OVER CAIRO DIVISION OF CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS RAILWAY TO NORRIS CITY.

Stokes, southeast corner of yard of J. Pyles store; iron post stamped "[illegible] ADJ"	414.623

Eldorado Quadrangle.

NORRIS CITY ALONG HIGHWAYS WEST AND SOUTH TO BROUGHTON, THENCE ALONG LOUISVILLE AND NASHVILLE RAILROAD TO ELDORADO, THENCE ALONG HIGHWAY EAST TO RIDGEWAY, THENCE NORTH TO OMAHA, THENCE OVER BALTIMORE AND AND OHIO RAILROAD TO NORRIS CITY.

Norris City, stone sill, at main entrance to north side of Cumberland Presbyterian Church; aluminum tablet stamped "444 ADJ"	443.856
Norris City, 3.5 miles west of, at northeast corner of Jennings school house; iron post stamped "410 ADJ"	410.032
Broughton, 3 miles north of, southeast corner of forks of road; iron post stamped "371 ADJ"	371.193
Broughton, northeast corner of cinder platform of L. & N. station; iron post stamped "379 ADJ"	378.676

	Feet.
Francis Mill, northeast corner of cinder platform; iron post stamped "371 ADJ"	371.116
Eldorado, 10 feet south of southwest corner of Grand Hotel; iron post stamped "388 ADJ"	387.904
Eldorado, 3.5 miles east of, at jog in road, 3 feet northeast of oak tree, in middle of road; iron post stamped "373 ADJ"	373.185
Zion Church, front wall, northeast corner; aluminum tablet stamped "390 ADJ"	389.882
Ridgeway, stone foundation of Catholic Church, southeast corner, east of front entrance; aluminum tablet stamped "377 ADJ"	377.120
Omaha, 90 feet south of station, 12 feet east of track; iron post stamped "367 ADJ"	367.101
Middlepoint, at northeast corner of cinder platform; iron post stamped "433 ADJ"	432.906

NEAR OMAHA EAST ALONG HIGHWAY 2.7 MILES.

Omaha, 2.7 miles east of, southwest angle of forks with road running south; iron post stamped "405 ADJ"	405.304

New Haven Quadrangle.

NEAR NORRIS CITY EAST ALONG HIGHWAY TO LITTLE CHAIN.

Iron, northeast corner of junction, 5 feet west of southwest corner of warehouse; iron post stamped "463 ADJ"	463.043
Herald, 3 feet east of northeast corner of school house; iron post stamped "430 ADJ"	430.063
Emma, southeast corner of junction 0.5 mile south of; iron post stamped "366 ADJ"	366.057
Little Chain, 1.0 mile west of, southwest corner of road forks; iron post stamped "367 ADJ"	366.816

NEAR EMMA SOUTH ALONG HIGHWAY TO INMAN AND WEST TO NEAR RIDGEWAY.

New Haven, at northwest corner of Scudmore and Mathia Bank; aluminum tablet stamped "370 ADJ"	370.221
Inman, southeast corner of forks of roads 0.5 mile east of; iron post stamped "379 ADJ"	378.348

NEW HAVEN WEST ALONG HIGHWAY TO BENCH MARK 2.7 MILES EAST OF OMAHA.

Omaha, 6.5 miles east of, northeast corner of junction with road running south, 12 feet west of hickory, 2 feet in diameter; iron post stamped "387 ADJ"	387.094

NEW HAVEN EAST ALONG HIGHWAY TO WABASH.

Ragland Island, 1.5 miles south of, just above Loop Slough, 75 feet south of large high water barn; iron pipe marked "U. S. Eng'r" (Engineers bench mark No. 38, elevation 343.802)	346.166
Ragland Island, 1.5 miles south of, 75 feet south of barn, 3 feet east of Engineers bench mark; iron post stamped "346 ADJ"	346.052

S. R. PATRICKS CHURCH EAST AND SOUTH TO ROUND POND SCHOOLHOUSE, THENCE NORTH TO WABASH RIVER.

Church, 0.75 mile south of, northeast corner of junction; iron post stamped "366 ADJ"	366.002
Round Pond, northeast corner of schoolhouse; iron post stamped "362 ADJ"	362.259

Galatia and West Frankfort Quadrangles—Franklin, Hamilton, Saline and Williamson Counties.—The elevations in the following list are based upon the precise level line of 1906 from Duquoin, and upon the 1907 adjustment.

The leveling was done mostly in 1906 by F. C. Higley. Two bench marks on West Frankfort quadrangle were established in 1907 by Henry Bücher.

The work was done in coöperation with the State and all permanent bench marks are stamped with the State name.

Galatia Quadrangle.

RALEIGH NORTH, TO NEAR WALPOLE, THENCE WESTERLY, TO POINT 2 MILES NORTH OF THOMPSONVILLE.

	Feet.
Raleigh, 2.73 miles north of, at township line road due north of Raleigh, at southeast corner, edge of section 3, T. 8 S., R. 6 E.; iron post stamped "400—1906"	401.576
Raleigh, 6.4 miles north of, north edge of section 21, T. 7 S., R. 6 E., county line, southwest of road corners; iron post stamped "381—1906"	381.803
Raleigh, 8.7 miles north of, 0.5 mile east of Walpole, 0.25 mile south of section line running through Walpole, southeast of road corner; iron post stamped "409—1906"	409.881
Walpole, 0.85 mile north of, 0.75 mile due north of Walpole, at intersection with township line road, southwest of crossing; iron post stamped "443—1906"	443.945
Walpole, 4.1 miles west of, at southwest corner of section 36, T. 6 S., R. 5 E., just northeast of road corner; iron post stamped "478—1906"	479.035
Walpole, 6.8 miles northwest of, 575 feet west of one-half section line of section 3, north side of New Haven road, 6 feet west of 6-inch walnut tree, at south road in J. Webber's field; iron post stamped " ? "	441.612
Walpole, 10.85 miles west of, county line, southeast corner of intersection of county line road and New Haven road, 40 feet east of county line; iron post stamped "593—1906"	593.904

RALEIGH SOUTH, TO TOWNSHIP LINE, THENCE WEST, TO ATTILA.

Raleigh, 1.6 miles south of, corner of sections 21, 22, 27 and 28, T. 8 S., R. 6 E., at southeast corner where road turns south; iron post stamped "373"	373.202
Raleigh, 4.28 miles south of, middle east and west of section 4, T. 8 S., R. 6 E., 0.33 mile south of township line, southeast of second right angle in road south; iron post stamped "363"	362.959
Raleigh, 7.41 miles southwest of, southeast of crossroads at Mt. Moriah Church, corner between Brushy, Raleigh and Harrisburg townships, 0.25 mile east; iron post stamped "459—1906"	459.397
Mt. Moriah, 2.94 miles west of, southwest of crossroads at center of Brushy township, at Voting House; iron post stamped "402—1906"	402.199
Saline county line, 0.5 mile west of, on east and west road which leads into Attila; iron post stamped "487—1906"	487.440

West Frankfort Quadrangle.

ATTILA WEST, TO WHITE ASH, THENCE NORTH, TO BENTON.

	Feet.
Attila, in front of two-story brick church; iron post stamped "558—1906"	557.950
Attila, 2.8 miles west of, near corner T. 8 and 9 S., R. 3 and 4 E., 58 feet north of railroad track and east of north and south township line road; iron post stamped "467—1906"	467.138
Pittsburg, block 21, lot 1, northwest corner, in front of drug store; iron post stamped "464—1906"	464.415
White Ash, about 2 miles east of, northeast of corner at witness tree, between railroad right of way and township line road; iron post stamped "477—1906"	477.547
White Ash, southwest of intersection of Chicago and Eastern Illinois Railroad White Ash switch and the Johnston City Marion road, 60 feet south of center of track; iron post stamped "449—1906"	449.027
Johnston City, 1.6 miles south of; at first crossroads north of Johnston City limits, in corner northwest of intersection; iron post stamped "459—1906"	459.749
West Frankfort, 2 miles south of, on first half section line north of county line at road crossing, 55 feet east of center of Chicago and Eastern Illinois track, southeast of road corner; iron post stamped "439—1906"	439.557
West Frankfort, across road, directly north of railroad station, 25 feet north of north side of walk, between railroad right of way and store wall; iron post stamped "408—1906"	407.969
West Frankfort, 0.81 mile south of, 1200 feet south of Chicago and Eastern Illinois coal chutes, at west road, southwest of road corner; iron post stamped "396—1906"	396.036
Benton, 4.76 miles north of, at township line road crossing, southeast of corner; iron post stamped "411—1906"	411.042

THOMPSONVILLE NORTH 2 MILES.

T. 4 and 6 S., R. 4 E., corner of sections 33, 34, 4 and 3, 3 miles west of county line, on township line, 30 feet southwest of road, 2 feet north of township line, in field of Akin Plaster; iron post stamped "459-1906"	460.476

WEST FRANKFORT WEST, TO CHICAGO, BURLINGTON AND QUINCY RAILROAD.

T. 7 S., R. 2 E., near southwest corner of section 22, dim crossroads, on south side of road, 8 feet north of fence, 40 feet west of fence corner, 30 feet east of 3 foot white oak; iron post stamped "396 ADJ"	396.036

WHITE ASH SOUTHWEST ALONG MISSOURI PACIFIC RAILROAD, TO SOUTHEAST CORNER OF SECTION 32, T. 9 S., R. 2 E.

T. 8 S., R 2 E., southwest corner of section 35, on north side of Coal Belt Electric railway at its junction with the Missouri Pacific Railroad extension to the Cartersville District Mine, 0.9 feet south of fence, 8.2 feet west of trolley pole and 270 feet west of line of the Coal Belt Electric Railway before it makes the curve to join the Missouri Pacific Railroad; iron post stamped "471 ADJ"	471.757

Alto Pass, Herrin and Murphysboro Quadrangles—Franklin, Jackson, Perry and Williamson Counties.—The elevations in the following list are based upon a precise level line of the U. S. Geological Survey from Duquoin to Shawneetown crossing Herrin quadrangle, and upon

the 1907 adjustment datum. Bench marks of the Coast and Geodetic Survey south of Duquoin on Illinois Central Railroad were not recovered.

For additional elevations on Herrin quadrangle refer to precise level list.

The leveling was done in 1907 by Henry Bücher.

The work was done in coöperation with the State and the permanent bench marks are stamped with the State name.

Herrin Quadrangle.

DUQUOIN SOUTH ALONG ILLINOIS CENTRAL RAILROAD, TO CARBONDALE.

	Feet.
Duquoin, 1.8 miles south of, in top of west wall concrete culvert No. 290—H, on "o" of 1902 in brass plate marked "Myers Construction Co., 1902, St. Louis"	434.280
Duquoin, 2.4 miles south of, west wall concrete culvert No. 290—81, brass plate marked as above	420.514
Duquoin, 2.5 miles south of, concrete culvert No. 291—01, in top of west wall at southwest corner of, 1.3 feet east of west edge and 1.8 feet north of south edge; aluminum tablet stamped "420 ADJ"	420.182
Duquoin, 2.5 miles south of, in west wall of same culvert, brass plate marked "Myers, etc."	420.175
Duquoin, 3.8 miles south of, concrete culvert No. 292—23, in top of west wall, brass plate marked "Myers, etc."	414.146
Duquoin, 4.4 miles south of, concrete culvert No. 292—88, top of west wall, brass plate marked "Myers, etc."	401.816
Elkville, 1.9 miles north of, culvert 293—58, top of west wall, brass plate marked "Myers, etc."	397.636
Elkville, 1.3 miles north of, culvert 294—05, in top of west wall, brass plate marked same as "Myers, etc."	398.696
Elkville, at north end of station platform; iron post stamped "Prim. Trav. Sta. 34—1906 400 ADJ"	400.509
Hallidayboro, 0.3 mile north of, culvert 296—60, top of west wall, brass plate marked same as "Myers, etc."	404.853
Hallidayboro, just south of station; top of rail at crossing	407.4
Hallidayboro, 0.8 mile south of, culvert 297—71, top of east wall, middle "c" of Chicago, in brass plate marked "Gilbert Spencer, Jr., Chicago 1902"	396.014
Hallidayboro, 1.1 miles south of, east wall of culvert 298—01, marked same as "Gilbert Spencer," etc.	395.086
Hallidayboro, 1.5 miles south of, east wall of culvert 298—42, brass plate marked same as "Spencer," etc.	390.364
T. 7 S., R. 1 W., near south quarter corner of section 32, 1.7 miles south of Hallidayboro, road crossing at southwest corner of, on south side of wagon road, 1.5 feet north of fence and 32 feet west of west southbound rail; iron post stamped "394 ADJ"	393.926
Ward station, north end of road crossing; top of west rail	409.1
DeSoto station, 0.6 mile north of, culvert No. 301—28, top of east wall marked same as "Spencer," etc.	386.701
DeSoto, 0.1 mile north of, east wall of culvert 301—78, just south of overhead crossing Missouri Pacific Railroad, brass plate marked same as "Spencer," etc.	390.830
DeSoto, about 120 feet south of station, in right of way at northwest corner of section house lot, 0.8 foot west of fence and 2.2 feet south of fence corner, 19 feet east of east rail; iron post stamped "401 ADJ"	401.732

Feet.

DeSoto, 2.2 miles south of, Illinois Central Railroad bridge No. 304—00 over Big Muddy river, at extreme southwest corner, in top of west wall, 2.3 feet from south end and 2.6 feet from west end; aluminum tablet stamped "392 ADJ" 392.004

NEAR CARBONDALE NORTHWEST, TO NEAR GLENAHL.

T. 9 S., R. 1 W., corner of sections 5, 6, 7 and 8, southwest corner of T road, west side of road, 0.8 foot east of fence, 24 feet south of fence corner; iron past stamped "397 ADJ" 397.474

FROM CHICAGO, BURLINGTON AND QUINCY RAILROAD WEST OF WEST FRANKFORT WEST ALONG ROAD, TO ELKVILLE.

T. 7 S., R. 2 E., northwest corner of section 19, at northeast corner of crossroads, on north side of road, 0.8 foot south of fence, 20 feet east of north and south fence line, on east side of north and south road; iron post stamped "398 ADJ" 398.210

T. 7 S., R. 1 E., southwest corner of section 24, at northeast corner of crossroads, east side of road, 0.7 foot west of fence, 2.6 feet north of fence corner; iron post stamped "393 ADJ" 393.030

T. 7 S., R. 1 E., northwest corner of section 28, southeast corner of crossroads, on south side of road, 1 foot north of fence, 6.8 feet east of fence corner; iron post stamped "440 ADJ" 440.360

T. 7 S., R. 1 W., center of northeast quarter of section 25, southeast corner of T road east, north of straight rail fence and east of fence corner; iron post stamped "395 ADJ" 395.293

T. 7 S., R. 1 W., west quarter corner of section 22, 0.25 mile east of, at T road to south, north side of road, opposite center of road to south; iron post stamped "391 ADJ" 391.645

FROM SOUTHEAST CORNER SEC. 32, T. 9 S., R. 2 E., WEST ALONG CHICAGO, BURLINGTON ELECTRIC RAILWAY, TO NEAR CARBONDALE.

T. 9 S., R. 2 E., corner of sections 31, 32, 5 and 6, opposite center of road to north, south side of road; iron post stamped "Prim. Trav. Sta. No. 10—464 ADJ" 464.756

Fordville, at southwest end of Carterville Herrin switch and "Y;" top of rail of Chicago Burlington Electric Railway 460.7

T. 9 S., R. 1 E., northeast corner of section 3, southwest corner of crossroads, west side of road, 0.7 foot east of fence, 6.7 feet south of fence corner; iron post stamped "431 ADJ" 431.057

T. 8 S., R. 1 E., southwest corner of sections 32, T road north, northeast corner of T on north side of road, 0.7 foot south of fence, 12.5 feet east of fence corner; iron post stamped "427 ADJ" 427.790

T. 9 S., R. 1 W., 0.3 mile southwest of northwest corner of section 1, T road west, east side of road opposite T, west of fence, north of fence corner (fence corner at north end of house lot); iron post stamped "488 ADJ" 488.601

T. 9 S., R. 1 W., northwest corner of section 10, southeast corner of crossroads; 0.7 foot west of fence, 11 feet south of east and west fence; iron post stamped "391 ADJ" 391.216

MURPHYSBORO QUADRANGLE.

FROM POINT 2.7 MILES SOUTH OF DUQUOIN WEST ALONG ROAD, TO SEC. 5, T. 7 W., R. 3 W., THENCE SOUTH, TO MOBILE AND OHIO RAILROAD.

T. 6 S., R. 2 W., quarter corner between sections 26 and 27, T road north, on south side of road, 1 foot north of fence and 38.5 feet west of field fence to south; iron post stamped "451 ADJ" 451.108

	Feet.
T. 6 S., R. 2 W., center of southwest quarter of section 29, T road to west, on south of road, 2 feet north of fence and 2.2 feet west of fence corner; iron post stamped "405 ADJ"	405.160
T. 6 S., R. 3 W., corner of sections 35, 36, 25 and 26, T road to south, north side of road, opposite T, 1.1 feet south of fence, 8 feet west of telephone pole, 21 feet east of small gate in fence; iron post stamped "409 ADJ"	409.238
T. 7 S., R. 3 W., northeast corner of section 5, 0.25 mile south of, southwest corner of T road west, south side of road, 0.7 foot north of fence and 11 feet west of fence corner; iron post stamped "396 ADJ"	396.593
T. 7 S., R. 3 W., center of section 17, second class road east, southeast corner of T, east side of road, west of fence and south of fence corner; iron post stamped "522 ADJ"	522.656

AVA EAST ALONG MOBILE AND OHIO RAILROAD, TO ORAVILLE, THENCE ALONG ROAD, TO HALLIDAYBORO.

Ava, southwest corner of station lot, 1 foot west of sidewalk; iron post stamped "Prim. Trav. Sta. No. 37, 1906—604 ADJ"	604.835
T. 7 S., R. 3 W., north quarter corner of section 29, 0.25 mile south of, 2 miles east of Ava, road crossing, east side of wagon road, 70 feet north of track, 25 feet north of north right of way fence, 1 foot west of fence; iron post stamped "521 ADJ"	521.714
Bryden, road crossing east of trestle 564 A, east side of wagon road, 35 feet north of track and 1 foot west of fence; iron post stamped "415 ADJ"	416.196
Oraville (Mobile and Ohio R. R.), at southeast corner of road crossing at station, east side of road and M. & O. R. R., 10 feet west of fence and 4.4 feet south of fence corner; iron post stamped "396 ADJ 1905"	395.944
T. 6 S., R. 2 W., east quarter corner of section 6, at northwest corner of crossroads, west side of road, 0.8 foot east of fence and 3.3 feet north of fence corner; iron post stamped "396 ADJ"	396.828
Finney station, Illinois Central Railroad (St. Louis-Padernal branch); top of rail	397.8
T. 7 S., R. 2 W., northeast corner of section 33, crossroads 0.5 mile north of Finney, southwest corner of crossroads, west side of road, 1 foot east of fence, 3. 7 feet south of fence corner; iron post stamped "396 ADJ"	396.299
T. 7 and 8 S., R. 2 W., corner of sections 1, 2, 35 and 36, west side of road, opposite center of T road east, by old rail fence, 4.8 feet north of telegraph pole; iron post stamped "404 ADJ"	404.824

NEAR GLENAHL WEST ALONG ILLINOIS CENTRAL RAILROAD AND ST. LOUIS IRON MOUNTAIN AND SOUTHERN RAILROAD, TO GRIMSBY.

T. 9 S., R. 2 W., in northwest quarter of section 12, at southwest corner of, west side of road, at road crossing 1.1 feet east of fence and on line with south right of way fence, 43 feet south of railroad; iron post stamped "397 ADJ"	397.004
Concrete culvert "G—86—09", top of north wall on middle of "c" of Chicago in brass plate marked "J. L. Fulton Co., Chicago 1898"	378.948
Murphysboro, County Courthouse, in northwest corner of lot; iron post stamped "Prim. Trav. Sta. No. ? 419ADJ"	419.542
Murphysboro, road crossing at station of St. Louis Iron Mountain and Southern Railroad; top of rail	409.5

Feet.

Murphysboro, 2.2 miles southwest of, water tank, in west face of most northern of concrete foundation piers; aluminum tablet stamped "367 ADJ" 367.603

GRIMSBY NORTH ALONG ILLINOIS CENTRAL RAILROAD AND HIGHWAY, TO AVA.

T. 8 S., R. 3 W., northeast quarter of section 33, road crossing of Illinois Central Railroad on east side of wagon road, 50 feet south of center of track, 30 feet north of southeast corner of right of way fence; iron post stamped "374 ADJ" 374.553

T. 8 S., R. 3 W., in southeast quarter of section 17, road makes jog to east then turns north, east side of road at point where private road turns south, 1 foot west of fence and 4 feet north of telegraph pole; iron post stamped "707 ADJ" 707.703

T. 8 S., R. 3 W., southwest corner of section 5, T road north, just south of Jones' farm house, at west side of road, 40 feet north of center of T and standing by old rail fence; iron post stamped "641 ADJ" 641.609

ALTO PASS QUADRANGLE.

AT GRIMSBY (Sandridge Post Office.)

Grimsby (Sandridge Post Office), northwest corner of T road north side of station, 1.5 feet south of fence, 6.5 feet west of fence corner iron post stamped "361 ADJ" 361.545

State Geological Survey Leveling—(See also portion of work on Baldwin and Chester Quadrangles.)

St. Charles Quadrangle—Kane County.—The elevations in the following list are based upon the 1903 adjustment. The leveling is tied to bench mark at Elgin and Ingalton of the Army Engineers and the U. S. Geological Survey respectively.

The leveling was done in 1907 under the direction of Dr. H. Foster Bain, State Geologist, by W. A. Gelbach, levelman.

ST. CHARLES QUADRANGLE.

ELGIN SOUTH ALONG ELECTRIC RAILWAY TO ST. CHARLES, WEST TO STATE BOYS' HOME AND RETURN, THENCE EAST ALONG CHICAGO AND GREAT WESTERN RAILWAY TO INGALTON.

Feet.

B. M. 86 of precise level line of Army Engineers: Elgin, corner of State street and Highland avenue, southwest corner, northeast corner of large brick building (Borden's Condensed Milk Factory); Horizontal bolt in watertable 6 inches from corner in north wall 717.485

Kerber's station, top of rail at crossing 734.0

South Elgin, front of hotel; corner of curb 710.292

South Elgin, southeast corner of street crossing of electric railway and street crossing Fox river bridge, 40 feet east of track, 15 feet north of road; in concrete post; aluminum tablet stamped "707 1907" 707.468

	Feet.
Coleman's Station, 1.2 miles south of; at Smith Young and Son's Riverview farm, 50 feet west of track, north side of road, in concrete post; aluminum tablet stamped "788 1907"	788.411
St. Charles Cemetery, northeast corner of, on point of land between Electric railway and wagon road, at junction; in concrete post, aluminum tablet stamped "787 1907"	786.976
St. Charles Home for Boys, in east part of farm, by fence at northeast corner of crossing; concrete post, aluminum tablet stamped "742 1907"	742.024
St. Charles Home for Boys, in watertable of schoolhouse, east wall, 3 feet from northeast corner; aluminum tablet stamped "802 1907"	801.819
St. Charles Home for Boys, opposite office, level with ground, 6 feet south of sidewalk; in concrete post; aluminum tablet stamped "794 1907"	794.223
St. Charles Home for Boys, northeast corner of farm, 4 feet west of corner fence post, in concrete post; aluminum tablet stamped "737 1907"	737.412
St. Charles, corner West Main and Weeks streets, northwest corner of crossing, in concrete post; aluminum tablet stamped "749 1907"	749.518
St. Charles, railway crossing just east of Chicago Great Western station, top of north rail	730.6
St. Charles, 2 miles east of, Chicago Great Western railway crossing on county boundary line east side of Kane county, 80 feet north of track, on east side of road; in concrete post; aluminum tablet stamped "755 1907"	755.356

The concrete posts mentioned in this list are 48 inches long, 6 by 6 inches square at top and 8 by 8 inches quare at bottom.

Kaskaskia River Survey—Mattoon, Ramsey, Shelbyville, St. Elmo, Vandalia and Windsor Quadrangles—Coles, Fayette and Shelby Counties.—Adjusted primary elevations along Kaskaskia river north of Keyesport, based upon 1907 adjustment. The original difference of elevation between Keyesport and Lerna by this line has been reduced 0.570 feet.

The leveling was done in 1907 by P. E. Fletcher, Resident Engineer, State Geological Survey.

Vandalia Quadrangle.

KEYESPORT ALONG HIGHWAY NORTH AND EAST, VIA VANDALIA AND HOLLIDAY, TO SHELBYVILLE, THENCE EAST ALONG CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS RAILROAD AND SOUTHEAST ALONG P. D. & E. R. R., TO LERNA.

	Feet.
T. 4 N., R. 1 W., northwest corner of northeast quarter of northeast quarter of section 31; iron post stamped "440"..................	440.030
T. 4 N., R. 1 W., southwest corner of section 22; iron post stamped "467"	467.494
T. 4 N., R. 1 W., northeast corner of section 15; iron post stamped "476"	475.755
T. 4 N., R. 1 E., southwest corner of northwest quarter of southwest quarter of section 6; iron post stamped "492"..................	492.228
T. 5 N., R. 1 E., southwest corner of section 29, 0.25 mile west of James Kling's residence; iron post stamped "505"................	504.876
T. 5 N., R. 1 E., 300 feet west of northeast corner of section 21; iron post stamped "516"..	516.305

	Feet.
T. 6 N., R. 1 E., 30 feet north of southeast corner of section 33; iron post stamped "466"	465.921
T. 6 N., R. 1 E., near southeast corner of section 16, at intersection of National and Shobonier road; iron post stamped "474"	474.031
T. 5 N., R. 1 E., 0.25 mile east of intersection of National road and section line of sections 12 and 13, in front of Bluff City (Clarksville) schoolhouse, on top of east wing of south abutment of U. S. Culvert	509.70

RAMSEY QUADRANGLE.

T. 6 N., R. 1 E., northeast corner of northwest quarter of southwest quarter of section 12, 0.75 mile north of Bluff City (Clarksville) schoolhouse; iron post stamped "507"	507.483
T. 7 N., R. 1 E., southwest corner of northwest quarter of southeast quarter of section 25, in front of B. F. Forbes' residence; iron post stamped "535"	535.421
T. 7 N., R. 2 E., southwest corner of northeast quarter of section 18, 0.25 mile north of Thomas Grandfield's residence; iron post stamped "501"	500.877
T. 7 N., R. 2 E., southwest corner of section 4; iron post stamped "506"	506.013

ST. ELMO QUADRANGLE.

T. 8 N., R. 2 E., southeast corner of northwest quarter of section 34; iron post stamped "509"	508.885
T. 8 N., R. 2 E., near southeast corner of northeast quarter of northeast quarter of section 23, northeast corner of Hogge Schoolyard; iron post stamped "580"	580.188
T. 8 N., R. 3 E., southeast corner of southwest quarter of southeast quarter of section 7; iron post stamped "594"	593.940
T. 8 N., R. 3 E., northeast corner of section 5; iron post stamped "589"	588.922
T. 9 N., R. 3 E., northwest corner of northeast quarter of northwest quarter of section 35; iron post stamped "610"	609.633
T. 9 N., R. 3 E., southeast corner of southwest quarter of section 10; iron post stamped "558"	557.562

SHELBYVILLE QUADRANGLE.

Cowden, 0.5 mile north by 1.0 mile east of, 600 feet west of southeast corner of section 34, T. 10 N., R. 3 E.; iron post stamped "607"	606.410
T. 10 N., R. 3 E., northeast corner of section 22; iron post not stamped	600.732
T. 10 N., R. 3 E., southwest corner of section 1; iron post not stamped	589.203
T. 10 N., R. 3 E., near northwest corner of southwest quarter of section 1, 0.5 mile north of above iron post; on cap of southeast leg of Morris bridge over Kaskaskia River	540.94
Surface of water; October 7, 1907	518.
T. 11 N., R. 3 E., northwest corner of section 31; iron post not stamped	606.221
Shelbyville, in south front of courthouse, on east end of second step; aluminum tablet not stamped	650.23

WINDSOR QUADRANGLE.

T. 11 N., R. 4 E., section 10, 1 mile west of Middlesworth, at intersection of north property line of Big Four Railroad and east section line; iron post not stamped	690.751

	Feet.
T. 11 N., R. 5 E., section 5, 3.5 miles southwest of Windsor, intersection of north property line of railroad and north and south quarter section line; iron post stamped "694"	693.705
Windsor, at intersection of north line of Big Four Railroad and Virginia Avenue; iron post stamped "712"	711.383
T. 12 N., R. 6 E., near northwest corner of section 33, in top of concrete post; aluminum tablet stamped "731"	730.386

MATTOON QUADRANGLE.

Gays, southwest corner of Block 14; in top of concrete post; aluminum tablet stamped "756"	755.623
T. 12 N., R. 7 E., section 20, at intersection of south property line of Big Four Railroad and east section line, in top of concrete post; aluminum tablet stamped "715"	714.178
Mattoon, at intersection of P. D. & E. R. R. and 21st street, in top of concrete post; aluminum tablet stamped "725"	725.03
Lerna; iron post stamped "755"	754.316

Beardstown, Clinton, Dawson, Decatur, Kenney, Lincoln, Mason City, Niantic, Petersburg, Saidora and Springfield Quadrangles—Cass, DeWitt, Logan, Macon, Mason, Menard and Sangamon Counties.—The elevations in the following list are based upon the precise line of the Army Engineers from Grafton to Chicago, and upon the 1907 adjustment.

The work was done by P. E. Fletcher, Resident Engineer, under the direction of Dr. H. Foster Bain, State Geologist, for the State Geological Survey of Illinois.

BEARDSTOWN QUADRANGLE.

BEARDSTOWN EAST ALONG HIGHWAYS, TO POINT ABOUT 12.7 MILES EAST OF.

	Feet.
Beardstown, east corner of Main and Washington streets, in top of stone step at main entrance to Odd Fellows Building, 0.5 foot from front edge and 1.4 feet north of south edge; copper bolt No. 26 marked "451.27"	444.351
Beardstown, 2 miles northeast of, at southeast corner of Louis Cemetery Lot; on stone post	454.80
Beardstown, 5.1 miles northeast of, on land of Ed. Davis, on south side of road, in root on north side of 30-inch cottonwood tree; boat spike (bench mark No. 130)	450.73
T. 18 N., R. 11 W., at northwest quarter of northeast quarter of section 16, at east entrance to brick schoolhouse; on northeast corner of stone step	477.42
T. 18 N., R. 11 W., at northeast corner of section 9; concrete post	443.17
T. 18 N., R. 11 W., section 12, 10.1 miles northeast of Beardstown, north of highway, in southeast corner of front yard of A. H. Krohe's farm house, 57.8 feet southeast of southeast corner of house; stone, pipe and cap No. 29	477.957

Saidora Quadrangle.

FROM POINT 12.7 MILES EAST OF BEARDSTOWN EAST ALONG HIGHWAYS, TO POINT 10.98 MILES EAST OF CHANDLERVILLE AND ABOUT 0.60 MILE WEST OF CASS AND MENARD COUNTY LINE. Feet.

T. 18 N., R. 10 W., near southwest corner of northeast quarter of section 9, at intersection of east line of section 9 with Beardstown and Chandlerville road, 2 feet west of Angus Taylor Jr. mail box, in 6-inch concrete post; aluminum tablet	504.245
T. 18 N., R. 10 W., section 10, on southeast side of road at Robert Fielding's farm house, in northeast corner of front yard, 97 feet north of northeast corner of house, stone, pipe and cap No. 30; top of cap (U. S. Engineers bench mark)	488.496
Chandlerville, on north side of River street, in back yard of Mrs. S. L. B. Chandler's residence, 26.75 feet east of center of track, 2.2 feet east of east right-of-way fence, 149 feet north of north fence of River street, 95 feet from northwest corner of the square upright part of Mrs. Chandler's residence, 79 feet north and 52.2 feet west from corner; stone, pipe and cap; top of cap (U. S. Engineers bench mark No. 31)	463.753
T. 19 N., R. 9 W., near northeast corner of southeast quarter of southeast quarter of section 33, in front of J. A. Harbinson's residence; on north root of 30-inch black oak tree	502.12
T. 19 N., R. 9 W., near southwest corner of southwest quarter of northwest quarter of section 36, in top of concrete post; aluminum tablet	496.807
T. 19 N., R. 8 W., northeast corner of northwest quarter of section 29, at southwest corner of intersection of crossroads, in top of 6-inch concrete post; aluminum tablet	483.616
T. 19 N., R. 8 W., 300 feet west of and 300 feet south of northeast corner of southeast quarter of southwest quarter of section 15; on west base of 12-inch black oak tree	498.353

Petersburg Quadrangle.

FROM POINT 10.98 MILES EAST OF CHANDLERVILLE EAST, TO OAKFORD, THENCE SOUTHEAST ALONG HIGHWAYS, VIA ATTERBURY, TO PETERSBURG.

Oakford, in H. Luke and Son's brick store building on north side of Center street, in foundation; aluminum tablet	495.159
T. 19 N., R. 8 W., southeast corner of southwest quarter of southwest quarter of section 7, at intersection of roads, in 6-inch concrete post; aluminum tablet	522.490
T. 19 N., R 7 W., southeast corner of southwest quarter of southeast quarter of section 11, on south side of north road fence to Kirby's barn yard, in southeast corner of yard, in top of 6-inch concrete post; aluminum tablet	550.818
T. 19 N., R. 7 W., near southeast corner of section 26, about 4.75 miles north of Petersburg, at fork of Bottom and Bluff roads, on south side of public road, in top of 6-inch concrete post; aluminum tablet	513.843
T. 19 N., R. 7 W., southwest corner of section 36, 20 feet north of east and west section line, 90 feet east of north and south section line; on base of hard maple tree 24-inches in diameter	574.638
T. 18 N., R. 7 W., 30 feet southwest of northeast corner of section 11, in northeast corner of James Mile's barn yard; on north base of 8-inch locust tree	603.87
Petersburg, Menard County Courthouse, in north wall, 2 feet east of entrance, 4 feet above walk; aluminum tablet stamped "524"	523.706

FROM A POINT ABOUT 2 MILES NORTHWEST OF GREENVIEW, TO A POINT ON THE BEARDSTOWN-PETERSBURG LINE ABOUT 6.7 MILES NORTH OF PETERSBURG.

	Feet.
T. 19 N., R. 6 W., northwest corner of northeast quarter of section 15; on corner stone	505.54
T. 19 N., R. 6 W., 700 feet west of northeast corner of section 20, iron bridge over Little Grove creek; on southwest corner of south abutment (Temporary bench mark)	509.31

SPRINGFIELD QUADRANGLE.

FROM SPRINGFIELD NORTHEAST ALONG RAILROAD AND HIGHWAYS, VIA RIVERTON, TO A POINT 1.3 MILES EAST.

Springfield, in water table on east side of Post Office, 12 feet from southeast corner; aluminum tablet stamped "599 ADJ"	598.997
Riverton, 2 miles southwest of, near southwest corner of Camp Butler National Cemetery, on north bannister of iron bridge; on button of name plate; marked "B—571—W—566 by previous survey"	567.36
Riverton, 0.25 miles west of, Wabash railroad bridge; on floor of, (Also equals assumed datum "36.95" of river gage)	540.31
Riverton, in southeast corner of stone threshold of opera house; aluminum tablet stamped "553 ADJ 1905"	552.796

DAWSON QUADRANGLE.

FROM A POINT 1.3 MILES EAST OF RIVERTON SOUTHEAST ALONG HIGHWAYS, TO A POINT ABOUT 2 MILES SOUTH OF MECHANICSBURG, THENCE NORTHEAST ALONG THE HIGHWAYS, TO A POINT ABOUT 1 MILE SOUTHEAST OF ILLIOPOLIS.

T. 16 N., R. 4 W., near southeast corner of northwest quarter of section 23, at intersection of public road on north and south quarter section line and public road northwest and southeast, in top of 6-inch concrete post; aluminum tablet	578.475
T. 16 N., R. 4 W., at southeast corner of section 25, in top of 6-inch concrete post; aluminum tablet	580.536
Mt. Zion, 4.8 miles east of, Jordan M. E. church; on northeast corner of concrete step at entrance	579.06
T. 16 N., R. 3 W., at southwest corner of section 33, in top of 6-inch concrete post; aluminum tablet	593.206
T. 15 N., R. 3 W., southeast corner of northwest quarter of section 2, in top of 6-inch concrete post; aluminum tablet	593.116
T. 15 N., R. 3 W., at northeast corner of southeast quarter of northeast quarter of section 1; on 12-inch hickory tree	596.93
T. 15 N., R. 2 W., northwest corner of southwest quarter of northwest quarter of section 5, in top of concrete post; aluminum tablet	599.186
T. 16 N., R. 2 W., in southeast corner of section 33, at southwest corner of crossroads, in corner of fence, in top of 6-inch concrete post; aluminum tablet	605.461
T. 16 N., R. 2 W., at southwest corner of section 24, at northeast corner of intersection of roads, in top of 6-inch concrete post; aluminum tablet	597.642
T. 16 N., R. 1 W., near northwest corner of southwest quarter of section 19, 50 feet southwest of main entrance to Riverside Cemetery; on west base of 30-inch black oak tree	601.68

Niantic Quadrangle.

FROM A POINT ABOUT 1 MILE SOUTHEAST OF ILLIOPOLIS EAST ALONG HIGHWAYS, TO A POINT ABOUT 3 MILES WEST OF DECATUR.

	Feet.
T. 16 N., R. 1 W., at northwest corner of southwest quarter of section 17, at southeast corner of crossroads, in top of 6-inch concrete post; aluminum tablet	572.216
T. 16 N., R. 1 W., near southwest corner of southeast quarter of southwest quarter of section 14, 150 feet north of northwest corner of Walnut Cemetery, in top of 6-inch post; aluminum tablet	606.805
Decatur, 14.1 miles west of, iron bridge; on east end of north concrete abutment of	584.52
T. 16 N., R. 1 E., at northwest corner of section 30, at southeast corner of roads, in top of 6-inch concrete post; aluminum tablet	584.471
T. 16 N., R. 1 E., 30 feet west and 20 feet north of southeast corner of northeast quarter of northeast quarter of section 15; in top of concrete post. 6-inches square; aluminum tablet	678.645
T. 16 N., R. 2 E., near southeast corner of northwest quarter of northwest quarter of section 17, in concrete post; aluminum tablet	666.390

Decatur Quadrangle.

FROM A POINT ABOUT 3 MILES WEST OF DECATUR, TO DECATUR, THENCE NORTHERLY ALONG ILLINOIS CENTRAL RAILROAD, TO A POINT ABOUT 1 MILE NORTH OF EMERY DEPOT.

Decatur, at northwest corner of intersection of North Main street and Wabash Railroad right-of-way, permanent bench mark; probably an aluminum tablet in the top of a concrete post	682.429
T. 16 N., R. 2 E., 20 feet north of north section line of section 2, 30 feet west of Illinois Central Railroad, in top of concrete post; aluminum tablet	680.833
Forsyth, 25 feet east and 1 foot south of station, in top of 6-inch concrete post; aluminum tablet	678.736
Forsyth, 1.9 miles north of, tile culvert marked "A—759—83," east retaining wall; on bronze name plate	680.75
Emery Station, 100 feet north of, 30 feet east of main track, in top of 6-inch concrete post; aluminum tablet	688.832

Clinton Quadrangle.

FROM A POINT ABOUT 1 MILE NORTH OF EMERY STATION ALONG ILLINOIS CENTRAL RAILROAD, TO CLINTON, THENCE SOUTHWEST ALONG ILLINOIS CENTRAL RAILROAD, TO A POINT ABOUT 2.7 MILES SOUTHWEST OF.

T. 18 N., R. 2 E., 20 feet north of south section line of section 11, 25 feet west of railroad, in top of 6-inch concrete post; aluminum tablet	701.528
Emery, 4.1 miles north of, at Maroa-Shellabarger's elevator, at northeast corner of main part of building; on second course of stone foundation	722.66
T. 19 N., R. 2 E., on south line of section 35, 20 feet north of Macon-DeWitt County Line, 25 feet west of track, permanent bench mark probably an aluminum tablet in top of concrete post	706.138
Clinton, DeWitt County Courthouse, in east end of first stone step at south entrance; aluminum tablet	745.923

Kenney Quadrangle.

FROM A POINT 2.7 MILES SOUTHWEST OF CLINTON SOUTHWEST ALONG ILLINOIS CENTRAL RAILROAD, TO A POINT ABOUT 2.25 MILES SOUTHWEST OF CHESTNUT, THENCE WESTERLY ALONG HIGHWAYS, TO A POINT 3 MILES NORTHEAST OF MT. PULASKI.

	Feet.
T. 19 N., R. 2 E., 600 feet south of southwest corner of northeast quarter of northeast quarter of section 6, 175 feet east of milepost marked "St.L—141," at west end of gate on south side of right-of-way, in top of 6-inch concrete post; aluminum tablet	743.950
T. 19 N., R. 1 E., on west line of section 12, 75 feet east of mile-post marked "St.L—139," in top of retaining wall of concrete bridge "D—153—98"; at northwest corner	686.67
T. 19 N., R. 1 E., on south line of section 10, 1 mile northeast of Kenney, on west wall of concrete arch over public road; on letter "O" in date on construction company's name plate	653.69
Kenney, 175 feet east of road crossing, 50 feet south of track, in top of concrete post; aluminum tablet	649.752
Kenney, 0.8 mile southwest of, west signal block concrete base; on northwest corner of	644.34

FROM A POINT 2.4 MILES SOUTHWEST OF KENNEY, TO SALT CREEK GAGE.

(Spur Line.)

Kenney, about 2.25 miles northwest of Kenney, Salt Creek bridge; on northeast iron post of	621.13
T. 19 N., R. 1 W., section 25, north side of railroad and on west side of wagon road, in top of concrete post; aluminum tablet	632.145
T. 18 N., R. 1 W., 1400 feet south of northeast corner of southeast quarter of section 5, 30 feet south of track, in concrete post; aluminum tablet	631.739
T. 18 N., R. 1 W., 30 feet north and 20 feet east of center of section 6, on farm of David Shellhamer; on southwest base of 18-inch elm tree	628.21

Lincoln Quadrangle.

FROM A POINT ABOUT 3 MILES NORTHEAST OF MT. PULASKI NORTHWEST ALONG HIGHWAYS, TO LINCOLN, THENCE WEST AND SOUTHWEST ALONG HIGHWAYS, TO A POINT ABOUT 2.3 MILES WEST AND NORTHWEST FROM GLENWOOD SCHOOLHOUSE.

T. 18 N., R. 2 W., at southeast corner of southwest quarter of section 35, about 3 miles north of Mt. Pulaski, in top of concrete post; aluminum tablet	613.326
Chestnut, 8.1 miles southwest of, 600 feet north of Pleasant Grove Church, at southwest corner of turn in road; on north base of 36-inch black oak tree	611.45
T. 19 N., R. 2 W., at southwest corner of southeast quarter of southeast quarter of section 30, in top of concrete post; aluminum tablet	584.96
T. 19 N., R. 2 W., 21 feet southeast of center of section 18, in top of concrete post; aluminum tablet	591.335
Lincoln, Courthouse square, 2 feet north of post at southwest entrance, in top of concrete post; aluminum tablet	590.856
T. 20 N., R. 3 W., 300 feet east of west line of section 36, 300 feet east of railroad; on east end of north concrete abutment	593.14
T. 20 N., R. 3 W., at northeast corner of southeast quarter of northeast quarter of section 33, at southwest corner of crossroads; in top of concrete post; aluminum tablet	615.411

	Feet.
T. 19 N., R. 4 W., 30 feet west of northeast corner of northwest quarter of northeast quarter of section 12, about 30 feet southwest of intersection of private T road south with east and west road; in top of concrete post; aluminum tablet	595.600

Mason City Quadrangle.

FROM A POINT 2.3 MILES WEST AND NORTHWEST OF GLENWOOD SCHOOLHOUSE NORTHWEST ALONG HIGHWAYS, TO A POINT ON THE CHICAGO AND ALTON RAILROAD 4 MILES SOUTH OF MASON CITY, THENCE TO A POINT 1.5 MILES NORTH OF GREENVIEW, THENCE WEST ALONG HIGHWAYS, TO A POINT ABOUT 2 MILES NORTHWEST OF GREENVIEW.

T. 19 N., R. 4 W., 500 feet north of southwest corner of southeast quarter of southwest quarter of section 2, 50 feet west of Millgrove schoolhouse; on west base of 30-inch walnut tree	593.790
T. 19 N., R. 4 W., about 30 feet northwest of southeast corner of section 5, in top of concrete post; aluminum tablet	554.89
T. 20 N., R. 4 W., 500 feet west of northeast corner of southwest quarter of section 31, at southwest corner of intersection of T road south with east and west road, in top of concrete post; aluminum tablet	524.261
T. 20 N., R. 5 W., at northeast corner of section 26, in southwest corner of intersection of roads, in top of concrete post; aluminum tablet	513.511
T. 20 N., R. 5 W., at northeast corner of section 29, in top of concrete post; aluminum tablet	546.471
T. 19 N., R. 6 W., 10 feet west of intersection of north line of section 13 and Chicago and Alton railroad, in top of concrete post; aluminum tablet	511.338

PRIMARY CONTROL.

Methods.

In order that the separate atlas sheets of the topographic map of Illinois may match exactly in position as they are extended from one end of the State to the other, it is essential that they be based on exact geodetic positions showing latitude and longitude of important points througout the area under survey, and azimuth or relation to true north and south of important lines. This work is started from careful base lines measured by the Coast Survey and the survey of the Great Lakes, which was executed some years ago. The coöperative survey starting from these extends by primary triangulation in some cases, and by lines of very careful primary traverse measured with compensated steel tape and large transits about the edge of each quadrangle under survey. The effect is to secure geodetic positions along the borders of these quadrangles on which to base all the adjustment of public land lines and all roads within the area of each, and assure the matching of the edges of adjacent sheets. The positions thus procured are permanently marked with metal posts or tablets, and will be of great utility hereafter as property becomes more valuable, in fixing definitely and permanently property lines and political boundaries. The

instructions under which this class of work is executed are appended hereto, as is a list of positions so determined both prior to and since coöperation. The necessary primary control upon which to base topographic mapping has been obtained by running careful transit lines between triangulation stations previously established by other Federal Bureaus, namely the Coast and Geodetic Survey, the U. S. Lake Survey and the engineer corps of the U. S. Army. These transit, or primary traverse lines are run by a party consisting of five men, the chief of party acting as observer, one recorder, two chainmen, and a rodman. The instrumental equipment consists of one good transit reading by vernier to 20″ to 30″; one 300-foot steel tape, one 100-foot steel tape, four hand recorders, two thermometers, two flag poles, and a good watch.

Each deflection angle is measured at least twice and if the measures differ more than 60″ additional measurements are obtained which do not differ by that amount.

Distances are usually obtained with the 300-foot tape, but when short sights only can be had, the 100-foot tape is used.

The true direction or azimuth of the line is obtained by observations on Polaris at stations not more than ten miles apart. It is customary to observe for azimuth on every clear night during the progress of the work. The tape when used is kept under a certain standard tension by means of a spring balance, and the temperature is taken at frequent intervals so that a correction can be applied when the measurements are made during extremely hot or cold weather. The line as run thus furnishes the necessary data from which as many geographic positions can be computed as desired. Usually such positions as roads crossings, railroad stations, etc., are computed at intervals of one mile, and the positions of the permanent station marked every eight miles.

Results of Primary Horizontal Control—1896 to 1908.[1]

Primary Railroad Traverse.—The following geographic positions were determined in 1896 from primary railroad traverse by Mr. George T. Hawkins, starting at Seehorn triangulation station of the Mississippi River Commission, and running along the Wabash Railroad to Springfield, connecting with United States Coast and Geodetic Survey astronomic pier in Capitol grounds; then from junction of Wabash with Chicago, Peoria & St. Louis Railroad at Jacksonville, along the latter road to Springfield via Havana, and from Havana to a point about ten miles northwest of Havana along the C., B. & Q. R. R.

HULL QUADRANGLE—PIKE COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Seehorn triangulation station	39 45 38.9	91 15 55.1
Junction of railroads at Hull	39 42 20.8	91 12 26.2
Kinderhook depot	39 42 05.5	91 09 16.3
Barry depot	39 42 01.4	91 02 27.4
Corner secs. 19, 30, 25, 24, T. 4 S., R. 5, 6 W.	39 41 54.5	91 01 46.9

[1] The work of 1896 to 1904 was prior to cooperation, and that of 1905 and 1906-07-08 was in cooperation with the State.

BAYLIS QUADRANGLE—PIKE COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Arden depot	39	43	17.5	90	56	36.9
Corner secs. 7, 18, 13, 12, T. 4 S., R. 4, 5 W	39	43	39.9	90	54	56.2
Baylis depot	39	43	41.8	90	54	30.4
New Salem depot	39	42	02.8	90	50	42.7
¼corner secs. 19, 24, T. S., R., 3, 4 W	39	42	01.6	90	47	59.1
Pittsfield Junction	39	42	01.7	90	47	45.0

NAPLES QUADRANGLE—PIKE AND SCOTT COUNTIES.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Griggsville depot	39	42	03.1	90	43	55.4
¼ corner secs. 23, 24, T. 4 S., R. 3 W	39	42	02.6	90	42	13.0
Valley City depot	39	42	22.0	90	39	07.9
Middle drawbridge at Valley City	39	42	23.6	90	38	44.1
Naples depot	39	45	09.6	90	36	26.2
Corner secs. 7, 18, 13, 12, T. 15 N., R. 13, 14 W	39	45	15.0	90	35	45.8
Bluffs depot	39	44	59.8	90	32	10.6

CHAPIN QUADRANGLE—MORGAN AND SCOTT COUNTIES.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Neeleys depot	39	45	20.5	90	28	34.8
Morganton	39	45	53.8	90	25	52.2
Chapin railroad junction	39	45	54.4	90	24	03.4
Center sec. 16, T. 15 N., R. 11 W	39	44	44.0	90	19	39.2
Markham depot	39	44	44.0	90	19	38.8
¼ corner secs. 13, 18, T. 15, N., R. 10, 11 W	39	44	42.4	90	15	41.5

JACKSONVILLE QUADRANGLE—MORGAN COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Jacksonville, junction Wabash and Chicago, Peoria and St. Louis railroads	39	44	11.9	90	13	11.0
Section corner 2 miles east of Jacksonville and 600 feet north of railroad	39	44	06.5	90	11	46.1
Arnold depot	39	43	19.0	90	08	40.3
Orleans depot	39	43	25.9	90	04	45.7
Alexander depot	39	43	26.4	90	02	21.0

NEW BERLIN QUADRANGLE—MORGAN AND SANGAMON COUNTIES.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Browns Crossing depot	39	43	27.0	89	59	04.4
Island Grove depot	39	43	27.2	89	57	39.3
Corner secs. 19, 30, 25, 24, T. 15 N., R. 7, 8 W	39	43	33.2	89	55	38.9
Berlin depot	38	43	27.6	89	54	42.6
Bates depot	39	43	28.1	89	50	54.9
Curran depot	39	44	30.2	89	46	17.5
¼ corner secs. 16, 21, T. 15 N., R. 6 W	39	44	31.8	89	46	17.1
Junction of Wabash and Chicago, Peoria and St. Louis railroads	39	44	38.1	89	45	43.9

SPRINGFIELD QUADRANGLE—SANGAMON COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Sanger depot	39	45	13.8	89	43	11.4
¼ corner secs. 7, 8, T. 15 N., R. 5 W	39	45	53.1	89	41	10.8
Junction of Wabash and Chicago and Alton railroads	39	46	19.0	89	39	09.0
Springfield pier (United States Coast and Geodetic Survey)	39	47	56.8	89	39	19.4

VIRGINIA QUADRANGLE—CASS AND MORGAN COUNTIES.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Corner secs. 3, 4, T. 15, 16 N., R. 10 W	39	47	09.2	90	12	38.2
Leiterberry depot	39	51	08.1	90	11	58.8
Corner secs. 2, 3, T. 16, 17, N., R. 10 W	39	52	23.6	90	12	06.8
Little Indian depot	39	53	14.3	90	12	06.6
Corner secs. 14, 15, 22, 23, T. 17 N., R 10 W	39	55	00.3	90	12	05.9
Railway junction, Virginia	39	56	58.5	90	12	05.1
¼ corner secs. 2, 35, T. 17, 18 N., R. 10 W	39	57	37.8	90	11	31.2
Anderson depot	39	58	54.7	90	09	35.7

SAIDORA QUADRANGLE—CASS AND MORGAN COUNTIES.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Chandlerville depot	40	02	59.7	90	09	08.6
Corner secs. 29, 30, 31, 32, T. 18, 19, N., R. 9 W	40	03	51.1	90	08	43.7
Corner secs. 7, 8, 17, 18, at Saidora	40	06	16.5	90	08	44.3
Saidora depot	40	06	17.8	90	08	44.3
Corner secs. 5, 6, 31, 32, T. 19 20 N., R. 9 W	40	08	00.6	90	08	44.7
Bath depot	40	11	28.4	90	08	19.0
¼ corner secs. 27, 34, T. 21 N., R. 9 W	40	13	50.7	90	06	20.8
Corner secs. 7, 18, 13, 12, T. 21 N., R. 8, 9 W	40	16	28.9	90	03	24.0
¼ corner secs. 17, 20, T. 20 N., R. 8 W	40	10	37.6	90	01	27.4
Kilbourne depot	40	09	08.3	90	00	43.7

ATTERBURG QUADRANGLE—MASON AND MENARD COUNTIES.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Oakford depot	40	06	09.2	89	57	55.1
Atterbury depot	40	03	36.4	89	55	29.9
Corner secs. 29, 30, 31, 32, T. 19 N., R. 7 W	40	03	41.3	89	55	21.7
Corner at Hilltop, 340 feet north of railroad	40	01	32.1	89	52	29.7
Petersburg depot	40	00	41.2	89	50	46.4

TALLULA QUADRANGLE—MENARD COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Corner secs. 19, 30, 25, 24, T. 18 N., R. 6, 7 W	39	59	21.8	89	49	38.8
Tice depot	39	59	07.7	89	47	42.8
¼ corner secs. 26, 27, T. 18 N., R. 6 W	39	58	57.9	89	45	07.7

SPRINGFIELD QUADRANGLE—SANGAMON COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Athens depot	39	57	53.1	89	43	27.9
Cantrall depot	39	56	14.8	89	40	32.4
Corner (?) secs. 15, 16, 21, 22, T. 17 N., R. 5 W	39	55	56.6	89	39	54.6
¼ corner secs. 27, 28, 1 mile north of Cora	39	54	38.6	89	38	42.6
Cora depot	39	53	45.7	89	38	07.0
Junction of Chicago and Alton with Chicago, Peoria and St. Louis railroads	39	49	51.5	89	38	03.8
Junction of Chicago and Alton with Baltimore and Ohio railroads	39	48	16.8	89	39	05.6

HAVANA QUADRANGLE—MASON COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Havana depot	40	17	37.2	90	03	56.0
West Havana depot	40	17	55.3	90	04	15.7
Center sec. 11, T. 4 N., R. 3 E	40	19	39.3	90	06	54.6
Corner secs. 1, 2, 11, 12, T. 4 N., R. 3 E	40	20	58.8	90	07	28.5
SW corner NE ¼ of NE. ¼ sec. 3, T. 4 N., R. 3 E	40	21	37.5	90	08	53.5

The following geographic positions were determined in 1897 by Mr. George T. Hawkins by primary traverse between Lake Survey triangulation station Fairmount and the Indiana-Illinois State line. Traverse follows the Wabash Railroad.

DANVILLE QUADRANGLE—VERMILION COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Fairmount triangulation station	40	01	35.8	87	50	48.8
Fairmount depot	40	02	48.6	87	49	54.2
Junction, Wabash and Chicago Eastern Illinois railroads	40	02	57.2	87	48	22.4
Catlin depot	40	03	45.3	87	42	13.9
Permanent bench mark at Catlin	40	03	53.8	87	42	02.8
One-fourth corner sections 24 and 25, T. 19 N., R. 12 W	40	05	12.8	87	40	03.4
Crossing at Tilton	40	05	54.4	87	38	53.4
Junction, Wabash and Chicago Eastern Illinois railroads	40	06	04.4	87	38	37.8
Danville, Wabash depot	40	07	30.7	87	37	31.2
Junction, Wabash and "Big 4" railroads	40	08	09.0	87	37	05.0
Corner sections 26, 27, 34 and 35, T. 20 N., R. 11 W	40	09	40.3	87	35	01.1
Crossing of Wabash Railroads and Indiana-Illinois State line	40	11	51.6	87	31	51.0

The following geographic positions were determined by primary traverse by Mr. George T. Hawkins, topographer, in August, 1901.

The line starts from an adjusted position established in 1899 near Evansville, and follows the Evansville and Terre Haute Railroad to Vincennes, where it was tied to the Coast and Geodetic Survey astro-

nomic pier. From a point on this line at Princeton, Ind., a line was run along the Air Line Railroad to Mt. Carmel, Ill., thence by Louisville & Nashville Railroad to Evansville, Ind., and tied to original point.

MOUNT CARMEL QUADRANGLE—EDWARDS AND WABASH COUNTIES.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Mount Carmel station, Air Line Railroad	38 24 16.2	87 45 25.7
Air Line and "Big 4" Railway Junction, point 300 feet southwest of, on "Big 4" Railway	38 24 34.2	87 46 27.8
T. 1 S., R. 12 W., center section 30	38 24 06.2	87 47 13.9
Sehrodt's, road crossing at	38 22 59.6	87 49 21.3
Keen station	38 21 08.8	87 52 02.6
T. 2 S., R. 13 W., one-fourth corner between sections 18 and 19	38 20 04.8	87 54 00.0
Cowling station	38 18 41.2	87 56 13.1
Grayville station, "Big 4" Railway	38 15 36.9	87 59 29.4
Grayville, crossing at ferry	38 15 27.7	87 59 27.7

CARMI QUADRANGLE—EDWARDS AND WABASH COUNTIES.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Calvin, one-fourth mile northeast of, corner on township line	38 12 59.6	88 00 38.8
Calvin station	38 12 36.0	88 01 01.7
T. 4 S., R. 10 and 11 W., corner sections 7, 12, 13 and 18	38 11 02.3	88 02 23.5
Crossville station	38 09 50.2	88 03 49.4
Road crossing, north and south	38 08 05.2	88 05 43.7
Carmi, junction of "Big 4" and Louisville and Nashville railroads	38 05 47.4	88 09 20.4

GEOGRAPHIC POSITIONS ALONG LOUISVILLE AND NASHVILLE RAILROAD FROM CARMI, ILL., TO MAUMEE, IND.

Position.	Latitude.	Longitude.
ILLINOIS.	° ′ ″	° ′ ″
Epworth ,road crossing at	38 04 17.7	88 06 20.2
T. 5 S., R. 10 W., corner sections 21, 22, 27 and 28	38 04 05.9	88 05 46.9
Maunee, road crossing at	38 02 10.5	88 02 45.9

Peoria Quadrangle—Peoria and Tazewell Counties.—The following geographic positions were determined by primary traverse run in 1902 by Mr. J. R. Ellis. Starting from adjusted position of the Chicago, Peoria & St. Louis Railway station at Havana, the line follows that railway to a point about 3.5 miles northeast of Parkland, thence north to Morton, thence north on Vandalia Railway to Farmdale, thence north and west through Peoria, thence west and south by wagon roads to Reed City, thence east by Toledo, Peoria & Western Railway to Pekin, thence southwest to point where line first left railway over Chicago, Peoria & St. Louis Railway.

GEOGRAPHIC POSITIONS ALONG THE CHICAGO, PEORIA & ST. LOUIS RAILWAY.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Havana station	40 17 37.2	90 03 56.0
Road crossing north and south (private)	40 29 51.3	89 43 07.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 24 N., R. 5 W., corner sections 29, 30, 31 and 32	40	29	37.0	89	42	07.7
T. 24 N., R. 5 W., corner sections 28, 29, 31 and 32	40	29	38.7	89	48	58.3
T. 24 N., R. 5 W., corner sections 26, 27, 34 and 35	40	29	39.9	89	38	41.2
T. 24 N., R. 5 W., corner sections 25, 26, 35 and 36	40	29	40.4	89	37	32.7
T. 23 and 24 N., R 4 and 5 W., corner of	40	28	49.2	89	36	22.5
T. 24 N., R. 4 W., corner section 28, 29, 32 and 33	40	29	41.8	89	34	05.5
T. 24 N., R. 4 W., corner sections 27, 28, 33 and 34	40	29	42.2	89	32	58.2
T. 24 N., R. 4 W., corner sections 26, 27, 34 and 35	40	29	42.9	89	31	49.9
T. 24 N., R. 4 W., corner sections 25, 26, 35 and 36	40	29	43.4	89	30	42.3
T. 24 N., R. 3 and 4 W., corner sections 25, 30, 31 and 36	40	29	43.9	89	29	34.4
T. 24 N., R. 4 W., ¼ corner between sections 25 and 30	40	30	10.6	89	29	34.7
Road, corner in	40	30	11.5	89	28	18.6
Road east and west	40	31	30.0	89	28	20.1
T. 24 N., R. 4 W., corner sections 7, 8, 17 and 18	40	32	22.1	89	28	37.7
T. 24 N., R. 4 W., corner sections 5, 6, 7 and 8	40	33	14.4	89	28	38.9
T. 24 and 25 N., R. 4 W., corner sections 5, 6, 31 and 32	40	34	06.6	89	28	42.2
Maple Grove school house, road corner at	40	35	25.3	89	28	30.6

GEOGRAPHIC POSITIONS ALONG THE VANDALIA RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Morton crossing of Tremont and St. Louis Railway	40	36	30.7	89	27	48.1
Road crossing east and west	40	37	25.5	89	29	00.2
Road crossing east and west	40	39	35.8	89	30	06.3
Road crossing north and south	40	40	16.1	89	31	21.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Three roads, junction of	40	40	57.7	89	33	13.4
Creek northwest, bridge over	40	41	41.8	89	32	26.7
Creek west, bridge over	40	42	49.0	89	31	46.6
Crossroads	40	43	30.7	89	31	24.5
T. 26 N., R. 4 W., corner sections 1, 2, 11 and 12	40	43	56.8	89	31	18.8
Pit and mound 45 feet south of road on top of hill	40	43	58.2	89	30	30.8
Illinois river, center draw to wagon bridge, over	40	43	27.9	89	32	52.9
Peoria, North Perry street and Abingdon avenue, corner of	40	42	35.3	89	34	17.6
Peoria, Knoxville and Frye avenues, corner of	40	42	44.4	89	35	38.8
Peoria. Elizabeth and Nebraska avenues, corner of	40	42	37.9	89	36	13.5
Peoria, Main and Franklin streets, corner of	40	41	59.4	89	36	33.6
Road west	40	42	17.0	89	38	08.9
Pottstown, railway crossing at	40	43	05.3	89	39	39.5
T. 9 N., R. 7 E., ¼ corner between sections 27 and 34	40	43	32.1	89	41	23.3
T. 9 N., R. 11 E., corner sections 27, 28, 33 and 34	40	43	32.2	89	41	57.6
T. road north	40	43	32.3	89	43	06.7
T. road east	40	43	06.1	89	44	50.1
T. 8 and 9 N., R. 7 E., ¼ corner between sections 6 and 31	40	42	39.9	89	44	50.6
Hale, crossing Iowa Central Railway at	40	41	29.3	89	44	49.6
T. 8 N., R. 6 and 7 E., corner 7, 12, 13 and 18	40	40	55.1	89	45	25.2
Gravel road east and west	40	39	38.3	89	46	07.6
T. 7 and 8 N., R. 6 and 7 E., corner 7, 12, 13 and 18	40	37	27.0	89	45	24.4
T. road east	40	36	20.8	89	45	23.6
T. road east	40	35	16.0	89	45	22.9

GEOGRAPHIC POSITIONS ALONG THE TOLEDO, PEORIA AND WESTERN RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Reed City, railway crossing at	40	34	32.5	89	45	03.2
Road crossing north and south	40	33	59.0	89	43	50.2
Road crossing north, east, south and west	40	34	21.2	89	42	31.5
Road crossing east and west	40	34	48.5	89	41	30.0
Orchard Mines, road crossing at	40	35	20.1	89	40	41.5
Pekin, center of draw in wagon bridge	40	34	22.3	89	39	18.2

GEOGRAPHIC POSITIONS ALONG THE CHICAGO, PEORIA & ST. LOUIS RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Chicago, Peoria & St. Louis Railway and Peoria & Pekin Union Railway, crossing at	40	33	38.8	89	39	21.8
Globe Distillery, east and west road crossing at	40	33	03.5	89	39	55.9
Road crossing east and west	40	32	16.1	89	40	44.7
T. 24 N., R. 5 W., ¼ corner between sections 17 and 20	40	31	22.8	89	41	35.0

Primary Quadrangle Traverse—Gallatin and White Counties—New-Haven Quadrangle.—The following geographic positions were located by primary traverse in 1903 by Mr. J. R. Ellis. The line starts from an adjusted traverse position at Maunee and follows highways, south to border of quadrangle; thence west to northwest corner of quadrangle; thence south along west border of quadrangle to Ridgeway; thence east to Uniontown, Ky., connecting at the latter place with spur line from Henderson, Ky.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Maunee, road crossing at	38	02	10.5	88	02	45.9
T. 6 S., R. 10 and 11 E., corner sections 1, 6, 7 and 12	38	01	29.2	88	02	29.8
T. 6 S., R. 10 and 11 E., quarter corner between sections 13 and 18	37	00	02.6	88	02	30.3
T. 7 S., R. 10 E., quarter corner between sections 23 and 26	37	58	52.3	88	04	10.3
T. 6 S., R. 10 E., corner sections 22, 23, 26 and 27	37	58	52.9	88	04	42.7
T. 6 S., R. 10 E., corner sections 21, 22, 27 and 28	37	58	53.4	88	05	49.7
Emma, crossroads at church in north part of	37	58	53.7	88	07	11.7
Emma, T road south at	37	58	40.7	88	07	08.5
Emma, crossroads 0.75 mile south of	37	58	01.4	88	07	13.3
T. 6 S., R. 10 E., corner sections 29, 30, 31 and 32	37	58	02.0	88	08	03.0
T. 6 S., R. 9 and 10 E., corner sections 25, 30, 31 and 36	37	58	02.7	88	09	08.6
R. 6 S., R. 9 E., corner sections 25, 26, 35 and 36	37	58	02.8	88	10	14.8
T. 6 S., R. 9 E., corner sections 26, 27, 34 and 35	37	58	03.2	88	11	21.5
T. road north	37	58	03.8	88	14	08.2
Range line road at T road east	37	57	51.0	88	15	09.8
Road at T road east	37	57	51.0	88	15	48.3
T. 6 and 7 S., R. 8 and 9 E., corner sections 31, 36, 1 and 6	37	57	11.2	88	15	48.2
T. 7 S., R. 8 and 9 E., corner sections 7, 12, 13 and 18	37	55	27.1	88	15	43.9
T. 7 S., R. 8 and 9 E., corner sections 13, 18, 19 and 24	37	54	36.0	88	15	43.9
T. 7 S., R. 8 and 9 E., corner sections 19, 24, 25 and 30	37	53	43.6	88	15	43.1
T. 7 S., R. 8 and 9 E., corner sections 25, 30, 31 and 36	37	52	50.1	88	15	44.3
T. road west	37	52	23.6	88	15	53.2
T. road west	37	51	30.0	88	15	02.5
T. road east	37	50	38.4	88	14	45.7
T. road east	37	49	47.8	88	14	48.0
T. road east	37	48	54.8	88	14	46.6
Ridgeway, crossroads 0.5 mile east of	37	48	02.2	88	14	46.9
T. 8 S., R. 9 E., corner sections 29, 30, 31 and 32	37	47	35.8	88	14	47.1
T. 8 S., R. 9 E., corner sections 28, 29, 32 and 33	37	47	34.5	88	13	40.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Continued.*

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 8 S., R. 9 E., corner sections 27, 28, 33 and 34	37 47 32.9	88 32 33.5
T. 8 S., R. 9 E., corner sections 26, 27, 34 and 35	37 47 33.4	88 11 29.9
T. 8 S., R. 9 E., corner sections 25, 26, 35 and 36	37 47 33.7	88 10 24.2
T road south	37 47 33.6	88 09 16.4
T. 8 S., R. 10 E., quarter corner between sections 30 and 31	37 47 33.0	88 08 45.3
Intersection of northwest and southeast road and road east to Sandy Ford	37 47 24.1	88 08 07.7
Intersection of roads at mouth of lane just east of sawmill	37 47 03.2	88 08 14.8
Schoolhouse, T road east about 2,000 feet south of	37 48 07.5	88 06 49.4
Schoolhouse, T road south at house about 3,000 feet north of	37 48 47.4	88 05 19.2

Gallatin, Hamilton, Saline and White Counties—Eldorado Quadrangle.—The line starts from adjusted traverse position at Ridgeway and follows Baltimore & Ohio Southwestern Railroad south to point about one mile northwest of Cypress Junction, thence along Louisville & Nashville Railroad through Equality, Eldorado, and Broughton to point 0.5 mile south of Dale, thence along north border of quadrangle by public highways, connecting with adjusted traverse position about five miles east of Norris City.

GEOGRAPHIC POSITIONS ALONG THE BALTIMORE AND OHIO SOUTHWESTERN RAILROAD.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ridgeway, street crossing Baltimore and Ohio Southwestern Railroad at station	37 47 59.0	88 15 36.9
Road crossing east and west	37 46 19.5	88 15 17.7
Bartley, east and west road crossing	37 45 17.3	88 15 09.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T road north	37 43 58.8	88 14 59.0
T. 9 S., R. 9 E., corner sections 17, 18, 19 and 20	37 43 58.9	88 14 48.2

GEOGRAPHIC POSITIONS ALONG THE LOUISVILLE AND NASHVILLE RAILROAD

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing north and south	37	43	46.1	88	17	03.8
Road crossing north and south	37	43	49.9	88	18	10.5
Equality, road crossing north and south just west of water tank	37	44	00.6	88	20	23.2
Equality, road crossing north and south 180 feet west of station	37	43	58.4	88	20	57.8
T. 9 S., R. 7 E., quarter corner between sections 12 and 13	37	44	53.3	88	22	53.8
Road crossing east and west	37	46	11.6	88	24	04.4
Road crossing north and south	37	47	25.5	88	25	06.2
Road crossing north and south	37	47	59.0	88	25	42.5
Eldorado, crossing Louisville & Nashville and Big Four railroads	37	48	53.8	88	26	00.1
Road crossing east and west	37	50	09.3	88	26	24.3
T. 8 S., R. 7 E., quarter corner between sections 9 and 16	37	50	09.2	88	26	14.3
Road crossing east and west	37	51	14.9	88	26	33.1
Road crossing east and west	37	52	19.7	88	26	41.8
Francis Mills, road crossing	37	53	38.5	88	26	52.2
Road crossing east and west	37	54	30.9	88	26	59.2
T. 8 S., R. 7 E., corner sections, 16, 17, 20 and 21	37	54	30.9	88	27	06.5
Road crossing east and west	37	55	12.0	88	27	06.4
Broughton, road crossing 500 feet north of station	37	56	15.9	88	27	35.5
Road crossing east and west near spur head block	37	57	41.9	88	28	23.3
Road crossing east and west	37	58	27.4	88	28	48.6
Dale, road crossing 0.5 mile south of	37	59	06.7	88	29	10.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T road north	37	59	06.4	88	22	03.7
T. road south at quarter corner	37	58	53.7	88	57	21.7
Road south	37	58	54.0	88	25	30.6
T. 6 S., R. 7 E., corner secs. 22, 23, 26 and 27	37	58	54.4	88	24	36.1
T. 6 S., R. 7 E., corner secs. 23, 24, 25 and 26	37	58	54.7	88	23	30.0
T. 6 S., R. 7 and 8 E., corner secs. 19, 24, 25 and 30	37	58	56.5	88	22	24.2
T. 6 S., R. 8 E., corner secs. 19, 20, 29 and 30	37	58	56.2	88	21	18.1
T. 6 S., R. 8 E., corner secs. 20, 21, 28 and 29	37	58	56.1	88	20	12.3
T. 6 S., R. 8 E., corner secs. 21, 22, 27, and 28	37	58	56.0	88	19	06.1
T. 6 S., R. 8 E., corner secs. 22, 23, 26 and 27	37	58	56.2	88	18	00.0
T. 6 S., R. 8 E., corner secs. 23, 24, 25 and 26	37	58	56.5	88	16	54.2
T. 6 S., R. 8 and 9 E., corner secs. 19, 24, 25 and 30	37	58	56.3	88	15	48.5

Geographic Positions Established in 1905-1906—Madison and St. Clair Counties—Belleville Quadrangle.—The following geographic positions on the United States standard datum were determined by primary traverse in 1905 by Mr. J. R. Ellis, assistant topographer. The line starts from United States Coast and Geodetic Survey triangulation station, Sugarloaf, follows highways south to Belleville; thence east along the Southern Railway to east edge of quadrangle; thence along highways north to northeast corner of quadrangle, connecting with Berger triangulation station and Parkinson triangulation station; thence west along highways to northwest corner of quadrangle, and south to Sugarloaf triangulation station.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Sugarloaf triangulation station: Near middle o north line of NE. ¼, sec. 20, T. 3 N., R. 8 W., on bluff overlooking American Bottom, 3 miles northwest of Collinsville on land of C. Witte, on top of prominent mound, which is 50 feet above the ground to the east and 150 to 200 feet above American Bottom on west. Station mark: A marble post 6 by 6 inches by 2½ feet long, top 1 inch above ground and marked thus: U. S. / C. & G. S.	38 42 05.3	90 00 27.5
Center of iron bridge near road corner	38 41 17.5	90 00 28.0
Collinsville crossing of Combs avenue and Clay street	38 40 05.9	89 59 41.0
Collinsville and Belleville road crossing Pennsylvania Railroad at electric power house	38 39 39.5	89 58 56.4
Collinsville, 3 miles southeast of; in southwest corner of stone foundation of Bethel Church, aluminum tablet stamped "Prim. Trav. Sta. No. 14, 1905."	38 38 41.1	89 57 42.1
T. 2 N., R. 8 W., secs. 10, 11, 14 and 15, road crossing near corner	38 37 17.9	89 57 58.3
T. 2 N., R. 8 W., quarter corner between secs. 22 and 23, T road east	38 36 20.8	89 57 58.2
Ridge Prairie saloon, crossroads at	38 35 33.4	89 57 58.1
Hy Pfeifer's saloon and hotel, 1 mile south of road west	38 34 23.8	89 57 57.7
T. road west at schoolhouse	38 33 35.9	89 57 56.2
Road crossing, O'Fallon branch Louisville and Nashville Railroad, 100 feet north of milepost 18	38 32 26.6	89 57 52.0
Belleville, street crossing Louisville and Nashville Railroad, main line	38 31 48.6	89 59 00.9
Belleville, in northeast corner of court-house yard, iron post stamped "Prim. Trav. Sta. No. 15, 1905."	38 30 47.3	89 58 50.3

GEOGRAPHIC POSITIONS ALONG SOUTHERN RAILWAY FROM BELLEVILLE EASTWARD.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Belleville, crossing of Southern Railway under Louisville and Nashville Railroad, near city reservoir	38 31 35.6	89 58 50.3
Mines, road crossing north and south	38 32 01.6	89 57 50.0
Road crossing north and south	38 32 00.9	89 56 49.3
T. 1 N., R. 8 W., quarter corner between secs, 13 and 14	38 32 01.4	89 56 49.3
Road crossing, north and south, 760 feet east of telegraph office	38 32 02.3	89 55 43.4
Shiloh station, milepost 22, road crossing north and south	38 32 02.8	89 53 55.7
Road crossing north and south between mileposts 23 and 24	38 32 00.7	89 52 07.6
Grassland on property of Chas. Griffin, northeast corner of postoffice, bears S. 85° 40′ W., distant 110 feet, iron post stamped "Prim. Trav. Sta. No. 16, 1905."	38 31 57.1	89 50 19.7
Road crossing north and south, 150 feet west of milepost 27	38 31 58.1	89 48 25.1
Road crossing north and south, 170 feet west of milepost 28	38 31 57.1	89 47 18.0

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
North and south road crossing of Southern Railway, near southwest corner of field of J. B. Freese, iron post stamped "Prim. Trav. Sta. No. 17, 1905."	38 31 55.6	89 45 38.9
T. 1 N., R. 6 W., near quarter corner between secs. 3 and 10, crossroads	38 33 13.8	89 45 06.6

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Continued.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Truss Bridge	38	34	04.0	89	45	07.6
T. 2 N., R. 6 W., quarter corner between sections 27 and 34, crossroads	38	34	57.5	89	45	07.2
Summerfield, in water table at southeast corner of public school building, aluminum tablet stamped "Prim. Trav. Sta. No. 18, 1905."	38	35	56.3	89	45	09.8
Berger triangulation station, near northwest corner of NE. ¼ of NW. ¼ section 22, T. 2 N., R. 6 W., on property of Doctor Berger, 1 mile north of Summerfield and 3 miles east and ½ mile north of village of Lebanon. Station mark: An earthenware pyramid marked "U. S. C. S.," 36 inches below surface, above which is a marble post 30 inches long and 6 inches square, marked [U. S. / C. & G. S.] its upper surface even with the ground.						
Western reference mark is a marble post 32 inches long, 4 inches square, in range with eastern row of trees in Doctor Berger's orchard; it is, as nearly as could be determined, on north boundary of section 22, which is boundary of Berger's land. Position of western reference mark	38	36	42.4	89	45	32.1
T. 2 N., R. 6 W., crossroads at 100 feet north to small bridge center	38	37	34.4	89	45	06.6
Crossroads 40 feet southwest to mail box, 36 feet northwest to culvert	38	38	13.8	89	45	09.1
T. 2 and 3 N., R. 6 W., quarter corner between sections 3 and 34, crossroads at; also line between Madison and St. Clair counties	38	39	18.8	89	45	11.4
T. 3 N., R. 6 W., quarter corner between sections 22 and 27, T road south	38	41	04.3	89	45	13.3
T road east, 160 feet south of iron bridge	38	41	57.5	89	45	47.8
St. Jacobs, crossroads at Nollbaner's hotel, in south part of	38	42	50.8	89	46	05.6
Crossroads at quarter corner between sections 11 and 14	38	42	49.5	89	44	08.4
Crossroads at quarter corner between sections 12 and 13	38	42	47.9	89	43	01.6
Parkinson triangulation station: On land of M. A. Parkinson, in middle of NE. ¼ section 12, T. 3 N., R. 6 W., and 1.5 miles west by south from Highland. Station mark: The vertex of a hollow square earthenware pyramid 3 feet below surface, with letters "U. S. C. S." cut on its sides, over which is a marble post 6 by 6 inches and 2.25 feet long, on top of which letters "U. S. C. & G. S." are cut. Reference marks: Two marble posts 5 inches square, 2.5 feet long, 2 inches above ground with a line diagonally across tops terminating in arrowhead, arrowhead pointing to station; northeast reference mark 18 feet 8¾ inches to station center; southeast mark 18 feet 8½ inches to station center; from center of northeast mark to southeast mark, 25 feet 8 inches; from station center to surveyors rock, 16 feet 9½ inches	38	43	26.9	89	42	44.3
Highland, about 2 miles west of; road crossing north and south, 480 feet east of water tank	38	44	02.9	89	42	48.3
In southwest corner of wood pasture owned by John Regel, iron post stamped "Prim. Trav. Sta. No. 19," corner stone in center of road bears S. 2° W., distant 17 feet	38	44	32.5	89	44	24.2
T road north, 16 feet northeast to cross on fence post, 19 feet northwest to west end of culvert	38	44	32.9	89	45	47.1
T road west at Marine cemetery	38	44	59.7	89	46	54.4
T road east 1.5 miles west of Marine cemetery	38	45	00.7	89	48	34.2
Silver Creek, national road over west fork of, center of iron bridge on	38	45	18.6	89	49	18.4
Troy, 5.2 miles northeast of; in northwest corner of pasture owned by Henry Wendler, at forks of road, iron post stamped "Prim. Trav. Sta. No. 20, 1905."	38	44	46.3	89	51	02.1
T. 4 N., R. 7 W., corner sections 27, 28, 33 and 34, T road south	38	45	32.3	89	52	27.7
T. 4 N., R. 7 W., corner sections 28, 29, 32 and 33, stone	38	45	32.1	89	53	35.1
T road west, 12 feet southeast to stone in north and south road	38	45	59.0	89	54	43.2

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD BETWEEN MONT AND PETERS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Mont, Illinois Central Railroad station	38 46 02.1	89 55 50.0
Suburban electric railroad crossing over Illinois Central Railroad	38 45 40.1	89 57 23.4
Glen Carbon, near Illinois Central Railroad station, on property of Madison Coal Co., southeast of Illinois Central Railroad station, iron post stamped "Prim. Trav. Sta. No. 21, 1905"	38 44 45.4	89 58 59.8
Peters station, road crossing north and south	38 44 30.9	90 00 07.3

Champaign and Piatt Counties—Mahomet Quadrangle.—The following geographic positions were obtained by primary traverse run by Mr. J. R. Ellis in 1905. The line starts from a position near Thomasboro located by primary traverse, follows highways west, south, and east near borders of quadrangle, and is connected with an adjusted traverse position near Tolono. Positions are given on United States standard datum.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 21 N., R. 9 E., corner sections 29, 30, 31 and 32, at crossroads	40 14 19.3	88 12 45.5
T. 21 N., R. 9 E., northeast corner section 36, iron post stamped "Prim. Trav. Sta. No. 8, 1905."	40 14 18.5	88 13 54.8
T. 21 N., R. 9 E., corner sections 25, 26, 35 and 36, at crossroads	40 14 18.5	88 15 03.4
T. 21 N., R. 8 E., corner sections 26, 27, 34 and 35, T road east	40 14 18.0	88 16 12.2
T. 21 N., R. 8 E., quarter corner between sections 27 and 28, crossroads	40 14 44.2	88 17 21.2
T. 21 N., R. 8 E., quarter corner between sections 28 and 29, crossroads	40 14 43.8	88 18 29.5
T. 21 N., R. 8 E., quarter corner between sections 29 and 30, crossroads	40 14 43.5	88 19 39.0
T. 21 N., R. 7 and 8 E., quarter corner between sections 25 and 30, T. road east	40 14 43.7	88 20 47.2
T. 21 N., R. 7 E., quarter corner between sections 25 and 26, T road east	40 14 43.0	88 21 54.0
T. 21 N., R. 7 E., in northeast corner section 35, stone to corner sections 25, 26, 35 and 36 bears N. 41°50′ E., distant 38 feet. Nail in blaze on east side of hickory tree bears S. 39°20′ W., distant 29.4 feet. Iron post stamped "Prim. Trav. Sta. No. 9, 1905"	40 14 16.4	88 21 54.2
T. 21 N., R. 7 E., quarter corner between sections 27 and 34, crossroads	40 14 16.9	88 23 36.6
T. 21 N., R. 7 E., corner sections 28, 29, 32 and 33, T road north	40 14 17.2	88 25 19.8
T. 21 N., R. 7 E., corner sections 29, 30, 31 and 32, T road north	40 14 17.4	88 26 28.6
T. 21 N., R. 7 E., corner sections 30, 31, west of T road east	40 14 17.4	88 27 36.9
T. 21 N., R. 6 E., corner sections 25, 26, 35 and 36, T road north	40 14 16.1	88 28 45.8
Mansfield, 1.5 miles north of; T. 21 N., R. 6 E., corner sections 26, 27, 34 and 35, 0.5 miles west of; in northwest corner of S. J. Trimmer's field at east and west road crossing, in limestone 30 by 10 by 8 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 10"	40 14 15.9	88 30 08.7
Mansfield, crossing of Wabash Railway and Big Four Railway	40 12 51.1	88 30 39.6
Mansfield, T. road north at cemetery 1.5 miles south of	40 11 34.6	88 30 19.3
T. road west	40 10 16.0	88 30 02.3
T. 20 N., R. 6 E., corner sections 26, 27, 34 and 35, crossroads at	40 09 23.6	88 30 01.9
T. 20 N., R. 6 E., south corner sections 34, 35, T road north near	40 08 44.1	88 30 01.5
T. 19 N., R. 6 E., quarter corner between sections 2 and 3, crossroads near	40 08 04.5	88 30 04.6
Centerville, 1 mile south of; at T road west, in ground, in pasture owned by W. L. Alexander, 1.5 feet from north and south fence on east side of road, in stone 8 by 9 by 30 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 11"	40 06 19.6	88 30 03.3
T. 19 N., R. 6 E., corner sections 22, 23, 14 and 15, T road east	40 05 53.6	88 30 03.3
T. 19 N., R. 6 E., corner sections 22, 23, 26 and 27	40 05 01.5	88 30 03.1
T. 19 N., R. 6 E., corner sections 26, 27, 34 and 35, T road west	40 04 08.8	88 30 03.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Continued.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 19 N., R. 6 E., south corner sections 34 and 35	40	03	16.8	88	30	02.9
T. 18 N., R. 6 E., corner sections 2, 3, 10 and 11, crossroads	40	02	24.1	88	30	02.4
T. 18 N., R. 6 E., corner sections 10, 11, 14 and 15, crossroads	40	01	31.4	88	30	01.9
T. 18 N., R. 6 E., corner sections 14, 15, 22 and 23	40	00	38.8	88	30	02.0
T. 18 N., R. 6 E., in northwest corner section 36, at crossroads, just inside of field and 3 feet from corner of hedge fence, iron post stamped "Prim. Trav. Sta. No. 12, 1905"	39	59	45.8	88	30	01.2
T. 18 N., R. 6 E., corner sections 23, 24, 25 and 26, crossroads	39	59	46.6	88	28	53.1
T. 18 N., R. 6 E., east corner sections 24, 25, T road west	39	59	47.0	88	27	44.6
T. 18 N., R. 7 E., corner sections 19, 20, 29 and 30, crossroads	39	59	46.9	88	26	39.0
T. 18 N., R. 7 E., corner sections 20, 21, 27 and 28, crossroads	39	59	47.3	88	25	30.4
T. 18 N., R. 7 E., corner sections 21, 22, 27 and 28, crossroads	39	59	47.5	88	24	22.1
T. 18 N., R. 7 E., corner sections 22, 23, 26 and 27, crossroads	39	57	47.5	88	23	13.5
T. 18 N., R. 7 E., in southeast corner section 23, near southeast corner of L. W. Schrader's barn lot, at crossroads, 15 feet east to maple tree, iron post stamped "Prim. Trav. Sta. No. 13, 1905"	39	59	47.6	88	22	05.6
T. 18 N., R. 7 E., east corner of sections 24 and 25, crossroads, is 15 feet south of corner	39	59	47.8	88	20	56.6
T. 18 N., R. 8 E., corner sections 19, 20, 29 and 30, crossroads	39	59	47.2	88	19	53.4
T. 18 N., R. 8 E., corner sections 20, 21, 28 and 29, crossroads	39	59	46.8	88	18	45.8
T. 18 N., R. 7 E., corner sections 21, 22, 27 and 28, crossroads	39	59	46.1	88	17	37.7
T. 18 N., R. 7 E., corner sections 22, 23, 26 and 27, crossroads	39	59	45.2	88	16	29.7

Logan, Menard and Sangamon Counties—Springfield Quadrangle.—The following geographic positions were obtained from primary traverse by Mr. E. L. McNair, topographer, in 1905. The line starts from adjusted position at Tice, follows wagon roads east, south, and west near border of quadrangle, and is connected with adjusted position at the crossing of the Wabash and Alton railways in South Springfield. Starting again from adjusted position at Athens the line follows wagon roads south along west border of quadrangle and is connected to adjusted position at Curran, at the crossing of the Wabash and the Chicago, Peoria & St. Louis railways. Positions are given on the Springfield astronomic datum.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Tice station	39	59	07.7	89	47	42.8
Tice, 3 corners 1.25 miles north of	40	00	15.7	89	47	41.6
T. 18 N., R. 6 W., quarter corner between sections 16 and 21	40	00	16.0	89	46	50.6
T. 18 N., R. 6 W., in northeast corner section 22, road south	40	00	02.8	89	45	45.4
T. 18 N., R. 6 W., in northeast corner section 23, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	40	00	10.5	89	44	17.5
Indian Point Presbyterian Church, road south, 1,800 feet west of T. 18 N., R. 6 W., section 24, northwest corner of	40	00	11.4	89	43	46.4
T. 18 N., R. 5 W., quarter corner northeast quarter section 19 and southeast quarter section 18 T road west	40	00	16.2	89	41	56.6
T. 18 N., R. 5 W., corner sections 16, 17, 20 and 21, T road east	40	00	17.1	89	40	31.8
T. 18 N., R. 5 W., corner sections 15, 16, 21 and 22	40	00	17.1	89	39	23.9
T. 18 N., R. 5 W., corner sections 14, 15, 22 and 23, 4 corners	40	00	17.7	89	38	14.7
T. 18 N., R. 5 W., corner between sections 23 and 24	39	59	51.9	89	37	06.3
T. 18 N., R. 4 and 5 W., quarter corner between sections 19 and 24, Fancy Prairie station, crossing C. & A. Railway just south of	39	59	52.2	89	35	58.7
T. 18 N., R. 4 W., quarter corner between sections 19 and 20, T road west	39	59	53.0	89	34	43.8
T. 18 N., R. 4 W., corner sections 16, 17, 20 and 21	40	00	19.7	89	33	35.4
T. 18 N., R. 4 W., corner sections 15, 16, 21 and 22, T road south	40	00	20.2	89	32	27.0
T. 18 N., R. 4 W., corner sections 14, 15, 22 and 23	40	00	20.5	89	31	19.2
C. & A. Railway, crossing of	39	59	30.6	89	30	44.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 18 N., R. 4 W., quarter corner between sections 26 and 35, 4 corners	39 58 36.6	89 30 43.6
T. 18 N. R. 3 and 4 W., corner sections 25, 36, 30 and 31, 4 corners	39 58 86.7	89 29 01.6
Williams, T. 18 N., R. 3 and 4 W., sections 25, 46, 30 and 31, in northeast corner of town of, 30 feet northeast of intersection of roads, iron post stamped "Prim. Trav. Sta. No. 2"	39 58 36.9	89 29 01.4
T. 17 and 18 N., R. 3 and 4 W., corner of, 4 corners	39 57 44.4	89 29 01.5
T. 17 N., R. 3 and 4 W., quarter corner between sections 12 and 7, T road north	39 56 26.0	89 29 00.6
T. 17 N., R. 4 W., quarter corner between sections 12 and 13, road west.	39 55 59.4	89 29 34.6
T. 17 N., R. 4 W., quarter corner between sections 13 and 24, T road east	39 55 07.1	89 29 34.3
T. 17 N., R. 4 W., quarter corner between sections 24 and 25, T road east	39 54 15.2	89 29 33.8
T. 17 N., R. 6 W., quarter corner between sections 25 and 36, 4 corners	39 53 22.8	89 29 33.3
T. 16 and 17 N., R. 4 W., quarter corner sections 1 and 36, 1.25 miles east of Barclay, 3.5 feet in ground, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	39 52 30.1	89 29 32.7
T. 16 and 17 N., R. 4 W., quarter corner sections 2 and 35, 0.25 mile east of Barclay, 4 corners	39 52 29.4	89 30 41.2
T. 16 N., R. 4 W., quarter corner between sections 2 and 11, T road north	39 51 37.0	89 30 40.4
Interurban Electric Railway, T. 16 N., R. 4 W., on line of sections 11 and 14, crossing of	39 50 44.4	89 36 23.0
T. 16 N., R. 4 W., center section 23, T road north	39 49 27.6	89 30 42.0
T. 16 N., R. 4 W., near center of section 24, 4 corners	39 49 28.4	89 29 48.0
T. 16 N., R. 4 W., on line sections 25 and 26, T road north	39 48 11.9	89 29 13.7
T. 16 N., R. 4 W., corner sections 25, 26, 35 and 36, T road south	39 48 12.4	89 30 05.8
T. 15 and 6 N., quarter corner section 2	39 47 19.6	89 30 31.2
T. 15 N., R. 4 W., northeast quarter section 11, T road east	39 46 13.9	89 30 12.7
T. 15 N., R. 4 W., quarter corner sections 13 and 14, 1.9 miles east of Rochester: near T road north, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	39 45 01.3	89 29 54.2
Rochester, T. 15 N., R. 4 W., southwest quarter of section 15, 4 corners.	39 45 00.8	89 32 03.2
T. 15 N., R. 4 W., in northeast corner section 17, T road south	39 45 12.4	89 33 35.5
T. 15 N., R. 4 W., in northwest corner section 17, T road south	39 45 21.2	89 34 08.5
T. 15 N., R. 4 W., quarter corner between sections 18 and 19, 4 corners	39 44 39.9	89 34 41.5
T. 15 N., R. 1 W., north part of section 3o, T road west	39 43 40.0	89 34 57.2
T. 15 N., R. 5 W., in northeast corner section 25, center of bridge over Sugar Creek	39 43 40.4	89 35 46.2
T. 15 N., R. 5 W., in southeast corner section 23, T road east	39 44 12.8	89 36 57.1
T. 15 N., R. 5 W., corner sections 14, 15, 22 and 23, Illinois Central railroad crossing	39 44 37.7	89 37 48.2
T. 15 N., R. 5 W., quarter corner between sections 15 and 22, 4 corners	39 44 36.6	89 38 38.2
Wabash and Alton railways, crossing of, T. 15 N., R. 5 W., in northeast corner of section 12	39 46 19.0	89 39 09.0
THENCE ALONG WEST BORDER OF QUADRANGLE.		
Athens station, T. 18 N., R. 6 W., in section 36	39 57 53.1	89 43 27.9
T. 17 N., R. 6 W., quarter corner between sections 11 and 12 4 corners	39 56 20.0	89 43 38.1
T. 17 N., R. 6 W., quarter corner between sections 12 and 13, 4 corners	39 55 27.6	89 43 37.0
T. 17 N., R. 6 W., center sections 24, 4 corners	39 54 35.4	89 43 19.0
T. 17 N., R. 6 W., section 23, center of pier of bridge over Sangamon river	39 54 27.5	89 44 32.8
T. 17 N., R. 6 W., quarter corner beteeen sections 27 and 28, T road south	39 53 43.7	89 45 47.3
T. 16 N., R. 5 W., center of southeast quarter section 3, T road W	39 51 46.4	89 45 15.4
T. 16 N., R. 6 W., near center section 10, in grass triangle near T road west, iron post stamped "Prim. Trav. Sta. No. 5, 1905"	39 51 14.2	89 45 32.3
T. 16 N., R. 6 W., north part section 22, 4 corners	39 49 44.7	89 45 30.1
T. 16 N., R. 6 W., north part section 27, T. road west	39 48 44.5	89 45 30.1
T. 16 N., R. 6 W., center section 34, T road north	39 47 39.4	89 45 28.0
T. 15 and 6 N., quarter corner section 3, T road south	39 47 13.2	89 45 12.1
T. 15 N., R. 6 W., quarter corner between sections 10 and 15, 1 mile northeast of Curran, near T road north, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	39 45 24.2	89 45 10.3
Wabash and Chicago, Peoria & St. Louis railways, crossing of	39 44 38.1	89 45 43.9

Champaign County—Urbana Quadrangle.—The following geographic positions on the United States standard datum were established from primary traverse run in 1905 by Mr. J. R. Ellis, assistant topographer. The line starts from east tower of Illinois State University at Champaign, located by triangulation of the United States Lake Survey; follows Illinois Central Railroad to Tolono; thence east along Wabash Railroad to Homer, connecting with Lake Survey triangulation station, Lynn Grove, and Lake Survey triangulation station chimney at Sidney; thence by wagon road north along border of quadrangle to Thomasboro; thence southwest along Illinois Central Railroad to starting point.

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD BETWEEN CHAMPAIGN AND TOLONO.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Champaign, east tower "Industrial School," U. S. Lake Survey triangulation station	40 06 32.9	88 13 37.8
Champaign, near southeast corner of Engineer Building, State University, in ground at cross sidewalks near; said building bears N. 26 15′ W., distant 52.5 feet, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	40 06 38.1	88 13 35.2
Champaign, road crossing, 1.25 miles south of (west track)	40 05 40.2	88 14 40.5
Savoy, road crossing, 1 mile north of (west track)	40 04 08.6	88 14 55.0
Savoy station, (west track)	40 03 14.8	88 15 03.5
Savoy station, road crossing, 1 mile south of (west track)	40 02 22.0	88 15 11.9
T. 18 N., R. 8 E., corner sections 11, 12, 13 and 14	40 01 29.3	88 15 15.6
Tolono, in southeast corner of lot at Commercial hotel; southeast corner of C. H. Bell's store bears N. 28 30′ E., distant 185 feet; southeast corner of hotel bears N. 40 E., distant 108 feet; iron post stamped "Prim. Trav. Sta. No. 2, 1905"	39 59 06.4	88 15 39.1

GEOGRAPHIC POSITIONS ALONG THE WABASH RAILWAY NEAR TOLONO.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Tolono, road crossing north and south, 1.25 miles east of	39 59 21.5	88 14 15.4
Tolono, road crossing north and south on section line	39 59 37.8	88 13 04.9

GEOGRAPHIC POSITIONS ALONG THE HIGHWAYS BETWEEN TOLONO AND SIDNEY.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 18 N., R. 9 E., corner sections 20, 21, 28, 29, at crossroads	39 59 45.9	88 11 56.9
T. 18 N., R. 9 E., corner sections 21, 22, 27 and 28, at crossroads	39 59 46.5	88 10 48.7
T. 18 N., R. 9 E., corner sections 22, 23, 26 and 27, at crossroads	39 59 47.1	88 09 40.9
T. 18 N., R. 9 E., corner sections 23, 24, 25 and 26, at crossroads	39 59 47.6	88 08 32.4
T. 18 N., R. 9 and 10 E., corner sections 19, 24, 25 and 30, at crossroads	39 59 48.3	88 07 24.1
T. 18 N., R. 9 and 10 E., corner sections 25, 30, 31 and 36, at crossroads	39 58 55.6	88 07 23.7
T. 17 and 18 N., R. 9 and 10 E., corner sections 1, 6, 31 and 36, at crossroads	39 58 03.3	88 07 23.3
Lynn Grove triangulation station: In SW. ¼ of SE. ¼ section 31, T. 18 N., R. 10 E., 3 miles southeast of Philo railway station. Station mark: A stone post 3 feet below surface with another directly over it as a surface mark	39 58 09.8	88 06 35.9
Black, east and west road crossing Frisco railway	39 58 02.4	88 05 09.0
T. 18 N., R. 10 E., corner sections 28, 29, 32 and 33, at crossroads	39 58 54.7	88 05 07.6
T. 18 N., R. 10 E., in southeast corner section 20, 4 feet from corner of hedge fence, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	39 59 48.7	88 05 08.1
T. 18 N., R. 10 E., quarter corner between sections 16 and 21 crossroads near	40 00 40.4	88 04 33.6
Sidney, Lake survey triangulation station chimney	40 01 25.4	88 04 10.0

GEOGRAPHIC POSITIONS ALONG THE WABASH RAILWAY EAST OF SIDNEY.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Sidney, crossing of Wabash and Frisco railways, 1 mile east of	40 01 30.6	88 03 25.7
Road crossing north and south between sections 11 and 12	40 01 40.5	88 01 43.6
Road crossing north and south between sections 7 and 12	40 01 47.2	88 00 35.0
T. 18 N., R. 14 W., near quarter corner west side section 7, in southwest corner of field and just off right of way, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	40 01 52.9	87 59 39.2

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 18 and 19 N., R. 11 E., and 14 W., 0.5 mile north of corner to sections 6, 6, 31 and 31, T road west	40 03 28.7	87 59 40.1
Clark school house, crossroads at	40 04 34.7	87 59 40.0
T. 19 N., R. 11 E., 14 W., corner sections 18, 18 and 19, 19, crossroads near	40 05 52.2	87 59 39.8
T. 19 N., R. 11 E., in northeast corner section 18, in corner of field owned by Lou Richards, 2.5 feet southwest of corner fence post and 133 feet south of Big Four railway, in limestone 40x7x5 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1905"	40 06 45.0	87 59 39.9
T. 19 N., R. 11 E., 14 W., corner sections 6, 6 and 7 and 7, crossroads	40 07 39.0	87 59 39.7
Ts. 19 and 20 N., R. 11 E., 14 W., corner sections 6 and 6 and 31 and 31, crossroads	40 07 31.8	87 59 39.7
T. 20 N., R. 14 W., west corner sections 30 and 31, at Union school house, T road east	40 09 23.9	87 59 39.8
T. 20 N., R. 11 E., 14 W., corner sections 19, 19 and 30, 30	40 10 15.2	87 59 39.6
T. 20 N., R. 14 W., west corner sections 18 and 19, T road east	40 11 06.9	87 59 39.7
T. 20 N., R. 14 W., west corner sections 7 and 18, T road east	40 11 59.1	87 59 39.8
T. 20 N., R. 14 W., west corner sections 6 and 7, T road east	40 12 50.7	87 59 39.9
T. 20 N., R 11 E., 14 W., north cor. sections 6 and 6, T. road south	40 13 29.8	87 59 40.2
T. 21 N., R. 11 E., southeast corner section 25, in southeast corner of Doctor McFarland's garden, corner sections 25, 30, 31 and 36, T. 21 N., R. 10 and 11 E., bears S. 43° E., distant 55 feet, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	40 14 23.1	88 00 06.2
T. 21 N., R. 10 E., corner sections 25, 26, 35 and 36; crossroads	40 14 22.6	88 01 15.1
T. 21 N., R. 10 E., corner sections 27, 28, 33 and 34, at Flatville	40 14 22.3	88 02 23.8
T. 21 N., R. 10 E., corner sections 28, 29, 32 and 33; crossroads	40 14 22.2	88 03 32.7
T. 21 N., R. 10 E., in northeast corner section 31 at crossroads, 1.5 feet from corner fence post, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	40 14 21.3	88 05 51.7
T. 21 N , R. 9 and 10 E., corner sections 30, 31, 36 and 25; crossroads	40 14 21.1	88 06 59.9
T. 21 N., R. 9 E., corner sections 25, 26, 35 and 36; crossroads	40 14 20.8	88 08 08.7
Thomasboro, crossroads 0.5 mile southeast of	40 14 19.6	88 11 02.0

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD BETWEEN THOMASBORO AND CHAMPAIGN.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 792, east and west road crossing 470 feet south of, east track	40 13 27.0	88 11 44.2
Leverett, east and west road crossing 1 mile north of, east track	40 12 00.8	88 12 20.3
Leverett, east and west road crossing, east track	40 11 21.2	88 12 36.8
T. 20 N., R. 9 E., sections 19 and 20, south corner of, T. road north	40 10 15.6	88 13 12.8
Milepost 787, east and west road crossing, east track	40 09 22.9	88 13 26.3
Milepost 786, east and west road crossing, 230 feet south of, east track	40 08 30.1	88 13 48.3
Illinois Central railway and Big Four railway, crossing of, north track Big Four, east track Illinois Central railway	40 07 17.9	88 14 17.7

Franklin, Hamilton, Saline and Williamson Counties—Galatia Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS, AKIN TO DALE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Three corners, road north to Akin	37	58	13.9	88	44	48.3
Akin, northwest corner of Chas. Crisps' Furniture store is southeast, northeast corner of main store is 85 feet west, southeast corner of McGuyers' store is 68.5 feet northwest, 1.5 feet west of sidewalk, in sandstone post, aluminum tablet stamped "Prim. Trav. Sta. No. 5	37	59	20.6	88	44	47.3
T. 6 S., R. 4 and 5 E., corner sections 24, 25, 29 and 30	37	58	53.5	88	42	18.7
Three corners, road north south and east	37	58	27.5	88	41	12.8
House of Granville Hungate, 3 corners, road north	37	58	41.6	88	40	23.4
Little Spring church, road opposite	37	58	27.0	88	38	34.8
T. 6 S., R. 5 E., center W. ½ sections 25, Flanagan Township, Hamilton county, bears 5.2 feet N. 83° 13′ W. southeast corner post of Perry S. Lee's orchard is 6.4 feet southwest, oak tree bears S. 66° 30′ W., 141.5 feet on north side of highway, in store post 3 feet by 8 by 6 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 6	37	58	27.2	88	36	28.7
T. 6 S., R. 5 and 6 E., on north and south township line, middle of east one-half section 25	37	58	27.2	88	35	39.6
T. 6 S., R. 6 E., at corner sections 19 and 30, on township line, 30 feet northwest—black oak tree 8 inches in diameter; 30 feet southwest—telephone pole	37	58	54.6	88	35	39.3
T. 6 S., R. 6 E., corner sections 19, 20, 30 and 31	37	58	54.4	88	34	33.2
T. 6 S., R. 6 E., corner sections 18, 19, 20 and 17	37	59	47.4	88	34	32.7
T. 6 S., R. 5 E., 4 corners sections 16, 17, 20 and 21	37	59	47.3	88	33	27.1
T. 6 S., R. 6 E., corner sections 15, 16, 21 and 22	37	59	47.8	88	32	21.1
T. 6 S., R. 6 E., corner sections 14, 15, 22 and 23	37	59	48.8	88	31	13.8
Dale, southeast of; at middle of, center W. rail L. & N. R. R	37	59	06.7	88	29	10.5

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD, ELDORADO TO HARRISBURG.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Eldorado, center of track at intersection of Louisville and Nashville and Big Four railways	37	48	53.8	88	26	04.1
Road crossing	37	48	16.2	88	27	17.7
Road crossing, east and west	37	47	29.5	88	28	48.2
Big Muddy creek, east end of trestle 427 over	37	45	52.2	88	31	12.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Harrisburg, in southwest corner of court house yard, iron post stamped "Prim. Trav. Sta. No. 1, 1906."	37	44	24.1	88	32	19.8
T. 9 S., R. 6 E., center section 17, crossroads	37	44	25.0	88	34	00.2
T. 9 S., R. 6 E., quarter corner between sections 17 and 18, T road south	37	44	24.4	88	34	33.5
T. 9 S., R. 5 and 6 E., quarter corner between sections 13 and 18	37	44	35.6	88	35	44.2
T. 9 S., R. 5 E., one-sixteenth corner between northeast quarter and southeast quarter section 14, crossroads	37	44	24.9	88	37	07.3
T. 9 S., R. 5 E., quarter corner between sections 14 and 15	37	44	24.4	88	37	58.9
T. 9 S., R. 5 E., one-sixteenth corner between northwest and southwest corners section 12, north side of road 1.5 foot south of fence line, 14 feet east of fence corner post, 3 feet southeast of telephone post, 33.5 feet northeast of center of corners, signboard "16 mi. to Marion; 5 mi. to Harrisburg; 8 to Galatia;" old barn in southeast of 4 corners, iron post stamped "Prim. Trav. Sta. No. 2, 1906"	37	44	24.4	88	38	47.3
Dallasania, 4 corners, one-sixteenth corner between northeast and southeast quarters of section 17, T. 9 S., R. 5 E.	37	44	24.7	88	40	27.2
T. 9 S., R. 4 and 5 E., quarter corner between sections 18 and 13, T road east on Saline-Williamson county line	37	44	24.0	88	42	21.7
T. 6 S., R. 5 E., quarter corner between sections 14 and 15	37	44	23.8	88	44	33.4
T. 9 S., R. 4 E., at middle south side of northwest quarter section 15, south side three corners, 2 feet north of wire fence; 82 feet west—fence corner, 530 feet north—southeast corner wagon shed west side of road, 361 feet east—line between a large oak and maple tree on opposite sides of road; road north to Atilla, east to Harrisburg, west to Marion; iron post stamped ""Prim. Trav. Sta. No. 3, 1906"	37	44	17.8	88	45	24.7

Franklin and Williamson Counties—West Frankfort Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing ,south end of plank bridge	37	45	17.8	88	45	23.3
Four corners	37	45	56.6	88	45	22.6
Station 101	37	46	37.8	88	45	40.0
T. 8 S., R. 4 E., corner secs. 27, 28, 33 and 34, 190 feet southeast of this district No. 8, Grant schoolhouse	37	47	31.4	88	45	40.3
T. 8 S., R. 4 E., sec, 28, 10 feet northeast of large oak tree east of Shiloh church	37	47	57.7	88	46	13.2
Corinth, center of 3 corners south of, 30 feet northeast of Dogwood tree	37	48	49.1	88	46	37.5
Three corners ,25 feet northwest—large fencepost corner	37	50	34.4	88	46	09.2
Small plank bridge, middle of, east and west, Williamson-Franklin county line	37	51	51.9	88	45	40.2
T. 7 S., R. 4 E., south corner road east, corner secs. 27, 28, 33 and 34	37	52	44.5	88	45	39.1
T. 7 S., R. 4 E., corner secs. 21, 22, 27 and 28	37	53	37.4	88	45	39.4
T. 7 S., R. 4 E., corner secs. 21, 22, 15 and 16	37	54	29.8	88	45	59.6
Thompsonville, in schoolyard, 52.4 feet to southeast corner schoolhouse, 79.6 feet north to large elm tree in corner of yard, 82.9 feet northeast to elm tree in corner of yard across street, iron post stamped "Prim. Trav. Sta. No. 4, 1906"	37	54	57.2	88	45	40.2
Three corners, road east	37	56	45.4	88	45	07.0
T. 6 S., R. 4 E., 3 corners in center of south half sec. 27, Franklin county 35 feet southeast—oak tree; 30 feet northeast—oak	37	57	43.8	88	45	05.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH AND WEST BORDERS OF QUADRANGLE.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Akin, at southeast corner, northwest corner Chas. Crisp's furniture store, is southeast, northeast corner of main store is 85 feet west, southeast corner of McGuyer's store is 68.5 feet northwest, 1.5 feet west of sidewalk, in sandstone post aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1906"	37 59 20.2	88 44 46.3
T. 6 S., R. 4 E., center sec. 21, road crossing	37 59 20.0	88 46 10.6
T. 6 S., R. 4 E., center sec. 20, 4 corners	37 59 20.0	88 47 17.5
T. 6 S., R. 4 E., and 3 E., on township line between Benton and Easton townships, secs. 19 and 14, north and south township line	37 59 20.6	88 49 13.1
T. 6 S., R. 3 E., corners between secs. 23 and 24	37 59 17.8	88 50 02.9
T. 6 S., R. 3 E., south half sec. 22, corner of Benton-Thompsonville and Aiken roads, west side of road, southwest corner of plank bridge on Benton-Thompsonville road—63 feet northwest; southwest corner of plank bridge on Akin road—34 feet northeast; sweet gum tree blazed on north side on east side of road, 77 feet southeast, elm tree 20 inches in diameter—6 feet northwest sweet gum tree—6 feet southwest	37 59 06.0	88 51 38.7
Three corners road west	37 59 36.2	88 52 33.7
Benton, center of C. & E. I. R. R. crossing	37 59 52.6	88 54 49.0
T. 6 S., R. 3 E., corner secs. 18 and 19, on township and range line between Benton and Browning townships and R. 2 and 3 E	37 59 43.4	88 55 41.7
T. 6 S., R. 2 E., at quarter corner between secs. 13 and 24, iron post stamped "Prim. Trav. Sta. No. 8, 1906"	37 59 41.5	88 56 14.7
Four corners	37 58 49.3	88 56 29.9
T. 6 S., R. 2 E., bears N. 49° 30′ E., corner stone secs. 25, 26, 35 and 36	37 57 56.6	88 56 46.5
T. 6 S., R. 2 E., quarter corner secs. 26 and 35	37 57 56.1	88 57 19.9
T. 6 and 7 S., R. 2 E., quarter corner between secs. 32 and 2	37 57 03.5	88 57 20.4
Middle Branch, center of bridge over	37 55 52.0	88 57 36.1
T. 7 S., R. 2 E., corner secs. 14, 15, 22 and 23, a black locust post at 3 corners road south	37 54 26.7	88 57 52.8
Public wells, road corner at, road east to west Frankfort	37 53 47.7	88 57 52.4
T. 7 S., R. 2 E., 3 corners road east, west and north, corner secs. 26, 27, 34 and 35	37 52 39.4	88 57 52.7
T. 7 S., R. 2 E., about center of south half sec. 33, at intersection of C. B. & Q. R. R., and an east west wagon road, iron post stamped "Prim. Trav. Sta. No. 9, 1906"	37 51 59.5	88 59 32.8

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 9 S., R. 2 E., approx. corner secs. 9, 10, 15 and 16, road north	37 44 44.8	88 59 00.0
T. 9 S., R. 2 E., corner secs. 10, 11, 15 and 14	37 44 44.3	88 57 52.7
Marion, corner of Marion ave., and North Court street, southwest corner, 26 feet southeast of is a maple tree at southwest corner of cemetery	37 44 35.5	88 55 55.0
Marion, center of north gate to Marion courthouse yard	37 43 55.1	88 55 35.3
T. 9 S., R. 3 E., corner secs. 17, 18, 19 and 20	37 43 50.6	88 54 37.2
Crab Orchard creek, center of iron bridge over	37 43 51.3	88 53 20.7
T. 9 S., R. 3 E., southwest corner of roads at corner secs. 14, 15, 22 and 23; stone to sec. corner is 47 feet northeast; a big dead oak on southeast corner is 58.5 feet east, southwest fence corner is 10 feet east, in post stamped "Prim. Trav. Sta. No. 11, 1906"	37 43 50.9	88 51 17.0
Road north	37 43 55.5	88 49 34.9
T. 9 S., R. 4 E., on ½ sec. line sec. 20 crossroads	37 43 51.7	88 47 17.8
Crab Orchard, 3 corners on Marion-Harrisburg road about 2.5 miles east of; on northwest quarter sec. 21, T. 9 S., R. 4 E., 75 feet northwest is southeast corner of red voting house, 20 feet east on corner is cherry tree	37 43 44.6	88 45 31.6

Franklin Williamson and Jackson Counties—Herrin Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing, east and west highway	37	49	12.6	89	00	55.4
Herrin, 0.5 mile north of; center crossing north and east public road and the C. B. & Q. R. R	37	48	50.7	89	01	28.5
Herrin, southeast corner public road and east Maple st	37	48	06.6	89	01	28.5
Stone at road corner road west to Mine No. 2	37	47	08.9	89	01	29.2
T. 8 S., R. 2 E., sections 31 and 32, T. 9 S., R. 2 E., sections 5 and 6, corner of, dead shell-bark tree in door-yard of Mr. Anderson is 95 feet southwest; section corner is about 18 feet north; south rail of electric railroad crossing is 50 feet north; mailbox post of L. Stottar is 3 feet southwest; iron post is 1.5 feet north of fence line, iron post stamped "Prim. Tra. Sta. No. 10, 1906"	37	46	28.7	89	01	12.3
T. 9 S., R. 2 E., corner sections 4, 5, 8 and 9, Baptist church is about 200 feet northeast	37	45	39.9	89	00	07.9
T. 9 S., R. 2 E., approx. corner sections 8, 9, 16 and 17	37	44	45.9	88	00	07.0

Madison and Clinton Counties—Breese Quadrangle.—The following geographic positions were determined by primary traverse in 1905 by Mr. J. R. Ellis. The line starts from an adjusted position on the Belleville quadrangle two miles west of Highland. The line follows Vandalia Railroad to Highland, thence east and south along highways to near southeast corner of quadrangle; thence west along highways to point three miles of New Baden where line is run west over Southern Railroad to Primary Traverse Station No. 17. The line was tied to Breese and Damainsville triangulation stations United States Coast and Geodetic Survey.

GEOGRAPHIC POSITIONS ALONG THE VANDALIA RAILROAD NEAR HIGHLAND.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Highland, road crossing 2 miles west of	38	44	02.9	89	42	48.2
Highland, road crossing 1 mile west of	38	44	19.8	89	41	52.9
Highland, road crossing at station	38	44	38.5	89	40	50.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
German Cemetery, road at 70 feet due N. to entrance	38	44	33.1	89	39	42.4
T. 3 and 4 N., R. 5 W., near corner to sections 2, 3, 34 and 35, 30 feet northwest to sycamore tree, 36 feet northeast to dead black oak	38	44	35.8	89	38	03.5
T. 3 and 4 N., R. 5 W., sections 1, 2, 35 and 36, center of road at hedge fence north	38	44	34.7	89	36	56.8
Fred Linenfilser, 400 feet west of his residence, in his pasture, 5 x 5 x 24 inch stone walnut trees bears N. 35° 45′ E., distance 40.4 feet, aluminum tablet in top of stone, stamped "Prim. Trav. Sta. No. 22, 1905"	38	44	35.1	89	36	40.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 3 and 4 N., R. 4 and 5 W., corner sections 1, 6, 31 and 36, also junction Madison, Clinton and Bond counties, 19 feet southwest to west end of small bridge, 29 feet southeast to U. S. mail box	38 44 35.6	89 35 49.9
T. road north, 15 feet north to center of small bridge	38 44 33.3	89 34 32.2
T. road south, 27 feet northeast to Wm. Frentiger's mail box	38 44 31.3	89 33 23.0
Jamestown, T. road north, one mile west of, 27 feet southeast to dead locust tree	38 44 03.2	,89 31 41.8
Jamestown public school grounds, near south line of, 57 feet east of southwest corner of same, southwest corner of school building bears N. 5° E., distant 144 feet, in top of dressed limestone 5 x 5 x 24 inches, aluminum in tablet stamped "Prim. Trav. Sta. No. 23, 1905"	38 43 59.7	89 31 06.9
T. 3 N., R. 4 W., corner sections 2, 3, 10 and 11, at crossroads, 37 feet northwest to corner yard fence, 36 feet southeast to cross on gatepost	38 43 36.1	89 31 07.2
T. 3 N., R. 4 W., corner sections 14, 15, 22 and 23, at crossroads, 30 feet northeast to cross on corner fencepost, 54 feet southeast to milk platform	38 41 51.1	89 31 03.6
T. 3 N., R. 4 W., west corner sections 23 and 26, center of road at fence east just north of schoolhouse	38 40 58.7	89 31 02.3
T. 3 N., R. 4 W., corner sections 26, 27, 34 and 35	38 40 06.5	89 31 01.0
H. Hinkam's farm, T. road west, 42 feet east to wild cherry tree	38 38 56.9	89 31 00.1
State road crossing with north and south road 24 feet north to cross on corner fence post, 63 feet southwest to cross on corner fence post	38 38 31.3	89 31 33.0
Breese, 1 mile north of; in northeast corner of Frank Budde's field, iron post stamped "Prim. Trav. Sta. No. 24, 1905"	38 37 30.4	89 31 32.0
Breese, Catholic church spire	38 36 32.0	89 31 44.3
Crossroads, 27 feet northwest to west end of stone culvert, 30 feet southeast to Hem. Ahler's mail box	38 35 47.0	89 32 06.4
Crossroads, 20 feet northwest to west end of culvert, 35 feet southwest to cross on telephone pole	38 34 54.6	89 32 06.1
Germantown, crossroads 1 mile north of; 18 feet north to center of bridge	38 34 02.2	89 32 06.3
Germantown, Catholic church spire	38 33 13.2	89 32 15.9

GEOGRAPHIC POSITIONS ALONG THE SOUTHERN RAILROAD NEAR SHOAL CREEK.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Shoal Creek, center of bridge over	38 32 46.4	89 30 47.5
Road crossing north and south	38 32 28.8	89 29 52.8

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. road south at large wooden cross	38 32 11.6	89 29 02.9
Bartelso, 1.25 miles southwest of; at T road north, in southeast corner of field owned by Herman Soole, nail in blaze on tree bears N. 76° 45′ E., distant 39.8 feet, iron post stamped "Prim. Trav. Sta. No. 25, 1905"	38 31 44.8	89 29 02.8
Murch's school house, T. road east, just south of, 25 feet northeast to cross on wild cherry tree, 31 feet southeast to corner wire fence	38 31 41.8	89 30 24.9
Germantown, T. road south 1.5 miles south of; 33 feet southeast to cross on post	38 31 47.1	89 31 31.8
Center of private road	38 31 44.2	89 33 00.9
T. 1 N., R. 4 W., corner sections 8, 9, 16 and 17, T. road north	38 32 16.1	89 33 12.3
T. 1 N., R. 4 W., corner sections 7, 8, 17 and 18, crossroads, 36 feet northeast to large apple tree, 37 feet southeast to locust tree	38 32 17.5	89 34 18.2
T. 1 N., R. 4 W., east corner sections 18 and 19	38 31 24.9	89 34 17.0

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 1 N., R. 4 W., corner sections 18 and 19 (west corner), 24 feet west to cross on rail fence	38	31	27.1	89	35	34.9
T. 1 N., R. 5 W., east corner sections 24 and 25, T. road west, 50 feet northwest to cross on fence, 39 feet west to south end of tile culvert	38	30	35.2	89	35	34.9
T. 1 N., R. 5 W., southwest corner section 24, 0.5 mile east of Damiansville, iron post stamped "Prim Trav. Sta. No. 26, 1905"	38	30	36.3	89	36	42.2
Damiansville, Catholic church spire	38	30	35.8	89	37	24.4
Damiansville school house, 1.25 miles west of; T. road east, 42 feet southeast to northwest corner of school house, 25 feet southwest to northeast end of small bridge	38	30	48.6	89	38	56.4

GEOGRAPHIC POSITIONS ALONG SOUTHERN RAILROAD NEAR NEW BADEN.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
New Baden, north and south road crossing about 3 miles east of; Southern Railroad crossing	38	31	54.3	89	38	57.0
Mile post 34, private road crossing	38	31	53.2	89	40	37.4
New Baden station	38	31	53.0	89	42	03.1
Milepost 31, road crossing north and south 170 feet west of	38	31	54.2	89	43	58.5
North and south road crossing of Southern Railway, near southwest corner of field of J. B. Freese, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	38	31	55.6	89	45	38.9

Menard and Sangamon Counties—Tallula Quadrangle.—The positions in the following list were determined by primary traverse in June, 1905, by Mr. E. L. McNair, topographer. The line begins at Brown's Crossing, on the Wabash Railway, at the western boundary of Sangamon county, and runs north on or near the county line to about the center of township 18 N., R. 8 W., Menard county, thence east to Petersburg.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Brown's Corners flag station; center of track at railroad crossing	39	43	27.0	89	59	04.4
T. 15 N., R. 8 W., sections 15 and 22, near quarter corner between T road west	39	44	23.7	89	59	04.9
T. 15 N., R. 8 W., section 10, near center of; in triangle of roads, at T road east, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	39	45	51.5	89	59	05.6
T. 16 N., R. 8 W., near center section 34, 3 corners, T road south	39	47	34.4	89	59	07.0
T. 16 N., R. 8 W., sections 27 and 34, quarter corner between, T road east	39	48	00.5	89	59	02.6
T. 16 N., R. 8 W., sections 21 and 22, quarter corner between, 3 corners, county line road to north	39	49	19.1	89	59	37.2
T. 16 N., R. 8 W., sections 9, 10, 15 and 16, corner of, T road east	39	50	37.4	89	59	37.8
T. 16 N., R. 8 W., sections 3, 4, 9 and 10, corner; T road east	39	51	29.7	89	59	38.2
T. 16 N., R. 8 W., sections 3 and 4, quarter corner between, 3 corners, T road to west	39	51	55.8	89	59	38.1
Ashland, 0.75 mile east of; T. 17 N., R. 8 W., sections 27, 28, 33 and 34, corner of; at intersection of roads, at northwest corner, iron post stamped "Prim. Trav. Sta. No. 8, 1905"	39	53	14.4	89	59	39.1
T. 17 N., R. 8 W., northwest corner of Sangamon county, T road to east	39	53	55.5	89	59	39.0
T. 17 N., R. 8 W., sections 15, 16, 21 and 22, corner of	39	54	59.6	89	59	39.8
T. 17 N., R. 8 W., sections 9, 10, 15 and 16, corner of, T road west	39	55	51.9	89	59	40.5
T. 17 N., R. 8 W., sections 3 and 4, quarter corner between, 4 corners	39	57	10.3	89	59	41.6
T. 17 and 18 N., R. 8 W., sections 4 and 33, quarter corner between	39	57	36.0	90	00	15.4
T. road south in western part section 28	39	58	53.8	90	00	43.6
T. 18 N., R. 8 W., sections 27 and 28, quarter corner between, T road south, county line between Menard and Cass counties	39	58	54.2	89	59	42.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 18 N., R. 8 W., sections 21, 22, 27 and 28, corner of	39	59	20.2	89	59	42.4
T. 18 N., R. 8 W., sections 15 and 16, quarter corner between, in grass triangle in center of road south and 25 feet south of center of east and west roads, 450 feet west of farm house of Amos Shoneweise, iron post stamped "Prim. Trav. Sta. No. 9, 1905"	40	00	38.2	89	59	42.6
T. 18 N., R. 8 W., sections 14 and 15, quarter corner between, T road to south	40	00	38.5	89	58	34.9
T road to north, in creek bottom	40	00	51.1	89	57	26.9
T. 18 N., R. 7 and 8 W., sections 13 and 18, quarter corner between, 4 corners	40	00	38.6	89	56	17.9
T road south in western part of section 17	40	00	39.2	89	55	02.8
T. 18 N., R. 7 W., sections 15 and 16, quarter corner between, T road south	40	00	39.2	89	53	03.3
Overhead crossing of Chicago and Alton R. R	40	00	39.5	89	51	36.8
Petersburg station, Chicago, Peoria & St. Louis Railway, center of track	40	00	41.2	89	50	46.4

Lake County—Waukegan Quadrangle.—In June, 1906, Mr. L. E. Tucker, topographic aid, ran a line of primary traverse around the borders of this quadrangle. Starting at Benton triangulation station, United States Lake Survey, and tieing to primary traverse post No. 1, of 1904.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Benton triangulation station, U. S. Lake Survey, in N. W. quarter of N. W. quarter of section 7, Benton township. Station mark. A stone post 2½ feet below surface, with another directly over it as a surface mark. Height of station used was 65 feet. Reference marks: Two stone posts, one S. 13° 04′ W., dist. 565.9 meters, one N. 68° 59′ E., 19.65 meters distant. Height of ground at station above mean sea level of Lake Michigan is 212.6 feet	42	29	02.8	87	52	43.3
T. 45 N., R. 12 E., quarter corner sections 7 and 8, four corners, North Prairie church on N. E. corner; schoolhouse on northwest corner	42	28	44.2	87	51	46.8
Chicago & Milwaukee and Electric railroad and Winthrop Harbor road, crossing of	42	28	43.9	87	50	41.9

GEOGRAPHIC POSITIONS ALONG CHICAGO AND NORTHWETERN RAILROAD, ZIONS CITY TO LAKE FOREST.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Zion City, corner of Shiloh Boulevard and Elijah avenue, northeast corner of American Express office 90 feet southwest	42	26	59.2	87	49	31.0
Zion City, Shiloh Boulevard and Chicago & Northwestern railroad crossing, west rail	42	26	59.0	87	49	04.4
East and West road crossing	42	23	04.8	87	49	26.3
Waukegan Courthouse	42	21	36.8	87	49	58.4
Chicago & Northwestern railroad and Elgin, Joliet & Eastern railroad, crossing of	42	19	29.9	87	50	20.6
Road crossing, east and west	42	18	32.2	87	50	46.8
Chicago & Northwestern and Chicago & Milwaukee Electric railroads, overhead crossing of	42	16	45.3	87	50	47.9
Chicago & Northwestern railroad, overhead crossing	42	15	27.7	87	50	28.2
Lake Forest, in southeast corner of city hall yard, at corner of Forest and Deerpatt sts., southeast corner of city hall bears N. 63° 30′ W., distance 34.5 feet; northwest corner of Chicago Tel. Co. building bears S. 41° 30′ E., distant 78.3 feet, iron post stamped "Prim. Trav. Sta. No. 12, 1906"	42	15	03.9	87	50	28.7
Chicago & Northwestern railroad and highway crossing	42	14	49.4	87	51	42.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 43 and 44 N., R. 11 and 12 E	42 14 23.8	87 53 09.4
T. 42 and 44 N., R. 11 E., sections 36 and 35 and 1 and 2	42 14 24.2	87 54 19.6
T. 43 and 44 N., R. 11 E., approximate corner sections 35, 34, 3 and 2	42 14 24.7	87 55 30.0
DesPlaines River, on south side of town line road, 9.8 feet southwest of corner of iron bridge across river; an 8 inch oak on opposite side of road is 22 feet north, iron post stamped "Prim. Trav. Sta. No. 13, 1906"	42 14 25.6	87 56 21.5
Milwaukee road and town line, corner of	42 14 25.3	87 56 39.7
Four corners east of railroad crossing	42 14 25.3	87 56 36.2
Wisconsin Central railroad, azimuth of, at station 69	152 01	....
Diamond Lake, in southwest corner of schoolhouse No. 76, Union; 5 feet north of schoolyard corner, southwest corner of schoolhouse is 83.6 feet northeast; southeast corner of house of Wm. Einzewam's is 20.5 feet northwest by west, iron post stamped "Prim. Trav. Sta. No. 14, 1906"	42 14 29.1	88 00 13.4
Elgin, Joliet & Eastern railroad, azimuth from station 77	282 51	....
Three corners, road east	42 15 18.5	88 00 05.0
Rockefeller, Hotel Cameron, center of street crossing	42 16 25.2	88 00 14.1
Wisconsin Central railroad and highway crossing	42 17 51.7	88 00 17.4
Four corners	42 18 21.5	88 00 15.2
T. 44 and 45 N., R. 10 E., and R. 11 E	42 19 39.9	88 00 16.3
Gages corners	42 20 19.2	88 00 16.1
Three corners, road west	42 21 37.8	88 00 06.5
Druses Lake, at 3 corners 600 feet north of north shore of, opposite to Brown's cottage, fence corner on west of road is 29.5 feet south, blazed oak 26.7 feet north; W. C. Brewer's mailbox post No. 4, at corner is 22 feet southeast; iron post stamped "Prim. Trav. Sta. No. 15, 1906"	42 22 17.8	88 01 12.8
Road crossing	42 23 09.6	88 00 14.5
T. 45 N., R. 10 E., sections 1 and 12	42 24 02.1	88 00 14.1
T. 45 N., R. 11 E., corner sections 6 and 7	42 24 02.1	88 00 14.1
T. corner	42 24 54.5	88 00 13.6
Four corners, road east and west northwest and southeast	42 26 39.4	88 00 37.4
Hickory Corners, an oak tree is 35 feet northeast, Methodist church is on southwest corner, mailbox No. 69 is 35 feet northwest	42 27 58.1	88 01 01.4
Three corners, road west, schoolhouse on northwest corner	42 28 24.1	88 01 04.5
Pikeville, Wis., 4 corner, south side state line road, west side N. & S. road, fence corner on southwest corner is 30 feet southwest	42 29 44.5	88 01 30.3
T. 1 N., R. 21 E., 50 feet northeast of south corner of sections 34 and 35, N. side state line road, 800 feet northwest Chas. Crawford's house, iron post stamped "Prim. Trav. Sta. No. 1, 1906"	42 29 42.5	87 59 24.6

Declination, N. border 3°05′; S. border 2°34′ W. border 3°48′.

Apple River, Galena, Lena, Mineral Point and Savanna Quads—Jo Daviess County.—The following geographic positions were determined by primary traverse by L. E. Tucker, in 1906. For the control of the Apple River quadrangle the line begins with Coast and Geodetic Survey position of White Church Steeple at Warren and follows the Illinois Central Railroad west to Scales Mound, thence along highways south to a point three miles west of Derinder, thence east along highways to three miles south of Moresville, thence north to Warren.

For control of the Galena quadrangle the line begins with adjusted position of Scales Mound, follows highways to a point about six miles northwest of Galena, thence south to Galena where it is tied to a position of Galena Spire and Horse Shoe Mound triangulation stations, thence south along the Chicago, Burlington and Quincy Railroad to Blanding station where it turns east along highways to adjusted position three miles west of Derinder.

Apple River Quadrangle.

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD NEAR NORTH BORDER OF QUADRANGLE.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Warren, white steeple at, Coast and Geodetic Survey triangulation station	42 29 35.95	89 59 20.2
Law station, center of track opposite operator's window	42 29 35.6	90 10 54.2
Law station, 0.6 mile west of; public north and south road crossing	42 29 21.4	90 11 33.9
Scales Mound, 1.5 miles northeast of; center of track over public road crossing	42 28 46.6	90 13 22.9

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
School house No. 4 (Mt. Morley), T. 28 N., R. 2 E., in southeast part of section 26, in angle of junction of ridge road and Elizabeth-Scales Mound road, school house bears N. 41° E., dist. 119 feet; a blazed oak is 12.4 feet west; iron post stamped "Prim. Trav. Sta. No. 18, 1906, ILLINOIS"	42 23 29.0	90 14 48.2
Hickory Grove school house, 1.8 miles north of, T road east, 35 feet east to Will Brockner's mail box	42 22 51.2	90 13 40.6
Hickory Grove school house, Elizabeth township, center of road opposite	42 21 17.7	90 13 53.8
Hickory Grove school house, 0.4 mile south of; 4 corners, mail box of H. Rees is on southeast corner	42 20 58.0	90 13 58.0
Apple River, 1.25 miles northwest of; junction of Elizabeth-Galena and Scales Mound Ridge road	42 20 07.5	90 14 53.3
Apple River, north end of iron bridge over	42 19 20.4	90 14 04.6
Elizabeth, corner of Main and Myrtle sts., corner Black Hawk building bears S. 89° 30′ W., 35 feet; corner of Illinois building bears N. 12° E., 45 feet	42 19 04.5	90 13 17.0
Elizabeth, at southwest edge of; public road crossing Chicago Great Western R. R	42 18 42.0	90 13 41.1
T. 27 N., R. 2 E., sections 25 and 36, approximate quarter corner between	42 17 54.0	90 13 38.8
T. 27 N., R. 2 E., section 36, T. 26 N., R. 2 E., section 1, quarter corner between	42 17 02.0	90 13 35.4
Pleasant Hill School, Hanover T., 43 feet south of northeast corner of fence, 126.6 feet north of white oak tree at southeast corner of yard and 11 feet northwest of large white oak; iron post stamped "Prim. Trav. Sta. No. 19, 1906"	42 15 54.3	90 14 07.9
T. 26 N., R. 3 E., approx. corner sections 7, 8, 17, 18, road south	42 15 15.0	90 11 43.7
Derinda Center, T. 26 N., R. 3 E., approx. corner sections 8, 9, 16 and 17, 4 corners	42 15 16.9	90 10 31.8
Big Rush Creek, west end of iron bridge over, T. 26 N., R. 3. E., approx. corner sections 9, 10, 15 and 16	42 15 17.4	90 09 20.5

Magnetic Declination of west border of quadrangle is 6° 07′ east.
Magnetic Declination of east border of quadrangle is 4° 57′ east.
Magnetic Declination of south border of quadrangle is 5° 15′ east.

Galena Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Scales Mound, set in the southwest corner of school house yard at two churches; corner of Presbyterian church porch is southeast 93.2 feet; southeast corner of Catholic church is west 51 feet; southeast corner of school house porch is northeast 70 feet; iron post stamped "Prim. Trav. Sta. No. 17, 1906"	42 28 31.6	90 15 07.9
Hesselbacher cheese factory, at T road east, northwest corner of factory	42 27 08.7	90 15 07.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Flint rock hill, T road west at top of	42 26 34.3	90 15 26.3
Lutheran church, gate in front of	42 25 53.6	90 15 37.5
Lutheran church, 0.7 mile southeast of; junction ridge road and Shappville road, 50 feet east to Robert Gill's mailbox	42 25 20.4	90 15 17.8
Lutheran church, 1.25 miles southeast of; junction of Scales Mound-Elizabeth ridge road and Thompsonville-Galena road	42 24 34.8	90 15 22.0
School house, No. 4, 0.7 mile northwest of; T road to east, mail box of H. J. Ehredt is by gate on west side of road	42 24 02.3	90 15 02.9
Scales Mound, 0.7 mile west of, wagon bridge over Illinois Central R. R., center of bridge	42 28 58.6	90 15 44.7
T. 29 N., R. 2 E., approx. corner sections 22, 23, 26 and 27	42 29 20.8	90 15 44.6
School house No. 92, Council Hill township, center of road opposite	42 29 58.3	90 18 59.4
T. 29 N., R. 2 E., west quarter corner section 19	42 29 49.8	90 20 34.1
T. 29 N., R. 1 E., east quarter corner section 26	42 29 49.5	90 20 34.1
Stone blacksmith shop, 3 corners	42 29 26.2	90 20 59.5
T. 29 N., R. 1 E., section 27, in east half of; 0.5 mile east of Millbrick, just east of ruins of old stone church, in northeast corner of T road, corner of fence bears S. 50° W., 8 feet; mail box of Travarthen bears S. 45° W., 75 feet; iron post stamped "Prim. Trav. Sta. No. 23, 1906"	42 28 55.0	90 23 27.2
Public road crossing railroad	42 29 39.0	90 23 42.1
Intersection of 4th principal meridian and Illinois-Wisconsin State line, 1 mile southwest of 4 corners, center of turnpike	42 29 48.6	90 26 33.6
T. 29 N., R. 1 W., approx. center section 23	42 29 49.1	90 27 24.8
T. 29, R. 1 W., section 28, in east part of southeast quarter of; 0.25 mile south of school house No. 3, on south side of Bodell's 4 corners (Menominee township); southeast corner of Bodell's front yard fence bears N. 1° W., 104 feet; mail box of Gehard Bussen bears N. 30° 30′ E., 87 feet; iron post stamped "Prim. Trav. Sta. No. 25, 1906"	42 28 50.2	90 29 16.3
T. 28 N., R. 1 W., near center of northeast quarter of section 2; 3 corners Galena-Hazel Green road and road to Excelsior, 18 feet east to east fence of turnpike	42 27 29.9	90 27 23.6
T. 28 N., R. 1 W., line between sections 2 and 11, intersection with Galena turnpike	42 26 47.6	90 27 17.0
T. 28 N., R. 1 W., corner sections 11, 12, 13 and 14	42 25 54.2	90 26 48.6
Galena, in most easterly corner of court house yard; east corner of court house bears S. 89° W., 24.5 feet; square stone on northwest corner of bench and Meeker streets bears S. 80° E., 14.7 feet; iron post stamped "Prim. Trav. Sta. No. 26, 1906"	42 25 06.3	90 25 31.0
Galena, German Lutheran church spire	42 25 02.6	90 25 53.0
Horse Shoe Mound triangulation station; about 1.25 miles southeast of Galena, on northwest end of Horseshoe Mound, on top of rock ledge, station mark: A Mississippi River Commission bench mark post had been broken off and thrown on ground, so exact location of station could not be identified	42 24 29.1	90 24 03.6

GEOGRAPHIC POSITIONS ALONG THE CHICAGO, BURLINGTON AND QUINCY RAILROAD, GALENA TO BLANDING.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Illinois Central R. R. and Chicago, Burlington and Quincy R. R. crossing at southwest edge of Galena	42 24 33.1	90 25 46.6
Galena Junction station, center of south end of	42 22 29.4	90 26 38.0
Galena Junction station, about 3 miles southeast of, east and west road crossing near culvert No. 168112	42 20 05.8	90 23 59.0
Blanding station, 1 mile northwest of; public road crossing	42 17 10.3	90 24 07.8
Blanding station, on west side of C., B. & Q. R. R. at corner in front of postoffice; 74 feet southwest to northeast corner of postoffice, 44 feet west to east corner Mrs. Botin's house; 44 feet east to northwest corner of Blanding station; iron post stamped "Prim. Trav. Sta. No. 27, 1906"	42 16 27.6	90 23 11.0
T. 26 N., R. 1 E., cor. secs. 2, 3, 10 and 11	42 16 09.2	90 22 27.1
T. 26 N., R. 1 E., line between secs. 11 and 12, north and south road crossing	42 15 38.3	90 21 16.1
T. 26 N., R. 1 E., quarter corner secs. 11 and 12	42 15 42.2	90 21 16.1
T. 26 N., R. 1 E., in southwest part of sec. 2, east and west road crossing	42 15 29.3	90 20 57.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 26 N., R. 1 E., southeast part sec. 12; 3 corners	42	15	29.7	90	20	25.4
Hanover, 3 miles west of; 3 corners road south, east and west	42	15	04.8	90	18	52.2
Hanover, 2.5 miles west of; oak tree on north side of road at 3 corners	42	14	58.0	90	18	14.0
Hanover, at southwest corner of Hanover hotel piazza wall, northeast corner of Hanover Manufacturing Company's brick block bears SW. 87.4 feet; northwest corner of Miller and White's brick store bears S. 61.6 feet; iron post stamped "Prim. Trav. Sta. No. 28, 1906"	42	15	24.7	90	17	06.8
Holy Face Catholic church, cor. Jefferson st., and Savanna road and Pleasant Hill road	42	15	21.3	90	16	33.4
Holy Face Catholic church, 0.5 mile east of; 3 corner road west to Hanover, east to Pleasant Hill	42	15	29.2	90	16	08.1

Magnetic declination of east border of quadrangle is 6° 07′ east.
Magnetic declination of west border of quadrangle is 6° 52′ east.
Magnetic declination of north border of quadrangle is 6° 25′ east.
Magnetic declination of south border of quadrangle is 5° 26′ east.

Mineral Point Quadrangle.

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Warren white steeple, Coast and Geodetic Survey triangulation	42	29	35.9	89	59	20.2
Warren, 1.5 miles northwest of; public road crossing	42	30	24.6	90	00	54.0
Apple River, in yard of W. H. Smith, in southwest corner of lot No. 10, block No. 16; southwest corner of Henry Smith's store is E. 64.5 feet; southwest corner of Henry Smith's house is N. 42.2 feet; iron post stamped "Prim. Trav. Sta. No. 16, 1906"	42	30	12.4	90	05	53.2
T. 29 and 30 N., R. 3 and 4 E., corner of	42	30	10.6	90	06	14.2
Law station, 2.0 miles east of; public road crossing	42	30	08.8	90	08	34.2

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Veda Grand, Illinois-Wisconsin State line, at elbow in road, 30 feet northwest to Wm. Haskin's mailbox; 20 feet east to corner of State line fence	42	30	27.4	90	16	20.5
T. 29 N., R. 2 E., approx. cor. secs. 15 and 16, corner of State line	42	30	27.0	90	16	56.0
T. 29 N., R. 1 E., sec. 15 on west half north line of, north and south road on the Illinois-Wisconsin State line	42	30	25.8	90	23	44.1
Intersection of fourth principal meridian and Illinois-Wisconsin State line	42	30	26.1	90	25	36.2
Intersection of fourth principal meridian and Illinois-Wisconsin State line, 0.5 mile west of; on south side of State line road, at corner of Galena-Hazel Green turnpike, 1 foot north of fence and 10 feet east of fence corner; a soft blazed maple tree on west side of turnpike and on State line bears NW. 77.7 feet; a cottonwood tree on northeast corner bears N. 53 ; iron post stamped "Prim. Trav. Sta. No. 24, 1906"	42	30	26.2	90	26	12.9

Magnetic declination of southwest border of quadrangle is 6° 25′ east.

Savanna Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH BORDER OF QUADRANGLE.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 26 N., R. 3 E., sec. 14, 3 corners on south line of; 0.5 mile south of Massbock postoffice	42 14 25.9	90 07 25.3
Camp Creek schoolhouse No. 14, Derinda township, in southeast corner of schoolhouse yard; southeast corner of schoolhouse bears N. 33° W., 81 feet; an oak tree 16 inches in diameter bears N. 42° E. 52 feet; iron post stamped "Prim. Trav. Sta. No. 20, 1906"	42 14 27.2	90 05 48.9
T. 26 N. R. 3 E., secs. 13 and 24, and T. 26 N., R. 4 E., secs. 18 and 19, approx. cor. of	42 14 26.9	90 05 48.0
T. 26 N., R. 4 E., cor secs. 17, 18, 19, and 20	42 14 23.9	90 04 54.7
T. 26 N., R. 4 E., northeast part of sec. 20; 4 corners of Galena-Dixon road	42 14 11.2	90 03 37.3
Carrott schoolhouse 21, Pleasant Valley township; T road	42 14 37.7	90 02 13.5
Pleasant Valley township hall, center of road in front of	42 14 24.1	90 02 02.4

Magnet declination of north border of quadrangle is 5° 15′ east.

Lena Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
White schoolhouse, just west of; T road south	42 15 07.6	89 59 25.1
T. 26 N., R. 5 E., sec. 7, in northwest quarter of; on south side of the Savanna-Freeport road, about 150 feet northeast of corner with Union church road; a wild cherry tree 22 inches in diameter bears S. 16° W., 9.6 feet; northeast corner of iron bridge over Muddy Plumb river bears S. 38° 30′ E., 366 feet; iron post stamped "Prim. Trav. Sta. No. 21, 1906"	42 15 42.0	89 58 29.7
T. 26 and 27 N., R. 4 and 5 E., (townships Pleasant Valley, Stockton Ward Grove and Berriman, corner of), T road east	42 17 01.4	89 58 43.4
T. 27 N., R. 4 E., secs. 25 and 36, T. 27 N., R. 5 E., secs. 30 and 31; corner of road east	42 17 54.0	89 58 45.0
T. 27 N., R. 4 E., cor. secs. 24 and 25, cor. of T road west at approx. cor. sec. 19 and 30, R. 5 E	42 18 46.9	89 58 47.0
T. 27 N., R. 5 E., secs. 18 and 19, corner road east	42 19 38.8	89 58 48.5
T. 27 N., R. 4 E., cor. secs. 13 and 24; road west	42 19 39.3	89 58 48.5
T. 27 N., R. 5 E., cor. secs. 7 and 18	42 20 31.5	89 58 50.2
T. 27 N., R. 4 E., secs. 12 and 13, corner of	42 20 32.3	89 58 50.2
T. 27 N., R. 4 E., cor. of road at secs. 1 and 12	42 21 24.9	89 58 52.4
T. 27 N., R. 5 E., cor. secs. 6 and 7, road east	42 21 23.9	89 58 52.4
School No. 82, Rush township, in school yard just south of plank walk leading from gate to schoolhouse; 1 foot west of fence, 4 feet south of center of gate; southeast corner of schoolhouse bears S. 73° W., 25.3 feet iron post stamped "Prim. Trav. Sta. No. 22, 1906"	42 22 43.3	89 58 56.0
Chelsea church, T. 28 N., R. 4 E., secs. 13 and 24, corner of public crossroads	42 24 55.6	89 59 00.7
T. 28 N., R. 5 E., secs. 18 and 19 (Town of Nora) road east	42 25 47.7	89 59 02.9
T. 28 N., R. 4 E., secs. 12 and 13 (Town of Rush) road west	42 25 48.4	89 59 02.9
Pucketts' schoolhouse, T. 28 N., (Nora), R. 5 E., secs. 6 and 7; corner of; crossroads	42 26 39.8	89 59 05.9
T. 28 N., (Rush) R. 4 E., secs. 1 and 2, corner	42 26 40.5	89 59 05.9
T. 28 and 29 N., R. 4 and 5 E., cor. of crossroads	42 27 33.2	89 59 07.2
Warren, 0.5 mile south of; T road west	42 28 22.0	89 59 08.6
Warren, White steeple, Coast and Geodetic Survey triangulation station	42 29 35.9	89 59 20.2

Magnetic declination of west border of quadrangle is 4° 57′ east.

Alto Pass, Carbondale, Duquoin, Herrin, Murphysboro and Pinckneyville Quadrangles—Franklin, Jackson, Perry and Williamson Counties.—The following geographic positions were determined by primary traverse by Mr. L. E. Tucker in 1906. A line was first run from Fountain Bluff triangulation station of the Mississippi River Commission, following the Illinois Central Railroad east via Murphysboro and Carbondale to the southeast corner of the Herrin quadrangle; then beginning with adjusted position at Carbondale the line follows the Illinois Central R. R. to Duquoin, thence east along public road to adjusted position at northwest corner of Thompsonville quadrangle.

For the control of the Murphysboro quadrangle, the line begins with adjusted position at Duquoin and follows public highways west to Denmark where it turns south and is tied to Fountain Bluff triangulation station.

Herrin Quadrangle.

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 1 E., secs. 5 and 8, quarter corner between	37	45	40.4	89	07	23.7
Four corners	37	45	39.4	89	05	42.3
Cartervilie city school yard, southwest part of, 1 foot north of east and west sidewalk, 1.3 feet west of line of north and south cross walk across alley, west side of cinder walk south from school house is 30 feet east; southwest corner of brick schoolhouse bears N. 57° 00′ E., 104 feet, iron post stamped "Prim. Trav. Sta. No. 31, 1906"	37	45	52.7	89	04	46.1
T. 8and 9 S., R. 1 E., corner secs. 34 and 35 and 2 and 3, stone post in center of 4 corners	37	46	29.0	89	04	36.1
Road north, quarter corner between sections	37	46	28.7	89	02	55.7
T. 8 and 9 S., R. 1 and 2 E., lane north, stone post at corner	37	46	28.6	89	02	22.3
B. M. No. 10, 1906, T. 8 S., R. 2 E., secs. 31 and 32; T. 9 S., R. 2 E., secs. 5 and 6, near corner	37	46	28.7	89	01	12.2
East and west road crossing about 2 miles north of Carbondale	37	45	39.4	89	13	11.7
Big Muddy river bridge about 2,000 feet south of; east and west road crossing	37	46	54.8	89	13	21.1
Crossing of Illinois Central and St. L. and I. M. R. R	37	49	16.4	89	13	38.6
Ward station, road crossing	37	51	01.9	89	13	51.5
Ward, 1 mile north of station; east and west road crossing	37	51	52.0	89	13	57.6
Hallidaysboro coal mine, just south of; east and west road crossing	37	53	05.0	89	14	05.2
East and west road crossing	37	53	55.5	89	14	07.0
Elkville station, 1 foot north of station platform, 10 feet west of northeast corner, 12 feet east of northwest corner, 16 feet east of east rail of Illinois Central railroad, and about 170 feet north of semaphore post, iron post stamped "Prim. Trav. Sta. No. 34, 1906"	37	54	41.5	89	14	08.4
Elkville, 0.8 mile north of; east and west road crossing	37	55	18.6	89	14	10.0
East and west road crossing	37	58	23.3	89	14	16.9
T. 6 S., R. 1 W., sec. 29, on half section line; 3 corners	37	58	23.3	89	14	15.8
Duquoin station, 1.2 miles south of; east and west road crossing	37	59	43.5	89	14	19.8

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Blue Grass schoolhouse, just east of; in northeast corner at crossroads, at T. 6 S., R. 1 E., corner secs. 16, 17, 20 and 21, iron post stamped "Prim. Trav. Sta. No. 33, 1906"	37 59 41.7	89 06 47.8
T. 6 S., R. 1 E., approx. corner secs. 16, 17, 20 and 21, nail in a blazed oak at southeast corner of crossroads bears S. 83 feet; nail in blazed oak at southwest corner of crossroads bears S. 36° W., 83 feet	37 59 41.5	89 06 48.0
T. 6 S., R. 1 E., approx. corner secs. 15, 16, 21 and 22, T road north	37 59 42.6	89 05 41.5
T. 6 S., R. 1 E., corner secs. 14, 15, 22 and 23, corner of, road north	37 59 42.2	89 04 34.2
T. 6 S., R. 1 E., quarter corner between secs. 14 and 23, road south	37 59 42.3	89 04 00.7
Three corners, roads south to Christopher, west to Duquoin, and north to Sisser station	37 59 42.1	89 03 10.4
T. 6 S., R. 1 and 2 E., point on township line in middle of north half section line between sec. 24, T. 6 S., R. 1 E., and sec. 19, T. 6 S., R. 2 E.	37 59 28.6	89 02 20.4
T. road south, 30 feet southeast to black locust tree	37 59 28.5	89 02 03.5
T. 6 S., R. 2 E., secs. 19 and 20, 3 corners on sec. line between, at point midway between the north full corner and the quarter corner	37 59 28.6	89 01 13.1
T. 6 S., R. 1 E., secs. 20 and 21, north and south road crossing Illinois Central railroad on section line between	37 59 17.2	89 00 06.0
Residence of W. N. Wolf, set on north side of, 150 feet south of Illinois Central railroad, on east of wagon road, iron post stamped "Illinois 1906 Elev. 438"	37 59 25.7	88 57 00.6
Bench mark No. 8	37 59 41.5	88 56 14.6

GEOGRAPHIC POSITIONS ALONG THE CHICAGO, BURLINGTON AND QUINCY RAILROAD.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Herrin, about 1 mile north of; east and west road crossing rail	37 49 12.7	89 00 55.4
Herrin, 0.5 mile north of; public road crossing northeast, north rail	37 48 50.7	89 01 28.5
Herrin, corner of Maple street and public road southeast	37 48 06.6	89 01 28.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Herrin, about 1.1 miles south of; T road west to mine No. 2, stone	37 47 09.0	89 01 29.2
T. 8 S., R. 2 E., secs. 31 and 32, T. 9 S., R. 2 E., secs. 5 and 6, on south side of road at corner of, a dead sheel bark hickory in dooryard of Mr. Anderson is 95 feet southwest; iron post stamped "Prim. Trav. Sta. No. 10 1906"	37 46 28.7	89 01 12.3
T. 9 S., R. 2 E., corner secs. 4, 5, 8, 9, 200 feet southwest of Baptist church	37 45 39.7	89 00 07.6

Declination S. border, E. 4° 41′; N. side E. 4 48′; W. side, 5° 21′.

Duquoin Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Duquoin, west rail main east track Illinois Central railroad, 37 feet northwest of northwest post of Duquoin station	38 00 43.0	89 14 22.0
Duquoin, east brick wall of Exchange bank of G. S. Smith & Co. about 4 feet above level of sidewalk and 3 feet south of east door of bank opening into Division St., aluminum tablet stamped "Prim. Trav. Sta. No. 32, 1906" Elev. 468	38 00 43.0	89 14 17.2
Duquoin, 0.6 mile southeast of; 5 corners	38 00 10.0	89 13 59.7
Ebenezer schoolhouse, T road south opposite, approx. center of sec. 12, T. 6 S., R. 1 W	38 00 09.5	89 11 46.5
Ebenezer, 0.8 mile northeast of public road crossing I. C. R. R. north rail	38 00 20.4	89 10 56.8
T. 6 S., R. 1 W., center sec. 11, T road north	38 01 01.9	89 10 39.6
T. 6 S., R. 1 W., quarter corner between secs. 11 and 12, (approx.) 4 corners	38 01 01.6	89 10 07.5
Three corners, road east to Benton, south to Mulkeytown and west to Duquoin	38 01 01.0	89 09 34.4
Little Muddy river, center of iron bridge over	38 01 24.2	89 08 16.4
Little Muddy river 1.2 miles east of; just south of Mr. Lindsay's house, 3 corners on sec. line, between secs. 4 and 5, T. 6 S., R. 1 E	38 01 39.7	89 06 50.3
Kone creek, schoolhouse, elbow corner	38 01 28.2	89 06 48.2
T. 6 S., R. 1 E., corner secs. 4, 5, 8 and 9	38 01 28.3	89 06 48.4
T. 6 S., R. 1 E., corner secs. 8, 9, 16 and 17, 0.25 mile north of; crossroads.	38 01 48.3	89 06 48.6

Pinckneyville Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Egyptian coal mine, just northeast of; L corner about the center of southeast quarter of northwest quarter of section 18, T. 6 S., R. 1 W., 20 feet northwest to honey locust tree	38 00 23.4	89 15 23.0
T. 6 S., R. 1 W., sec. 18, T. 6 S., R. 2 W., sec. 13, quarter corner between	38 00 09.4	89 15 55.9
T. road south, opposite, stone in road	38 00 08.6	89 16 29.5
T. 6 S., R. 2 W., approx. quarter corner between secs. 14 and 15	38 00 09.1	89 17 52.7
T. 6 S., R. 2 W., road south, private road north, center sec. 16	38 00 10.6	89 19 32.5
T. 6 S., R. 2 W., quarter corner between secs. 17 and 18, T road south	38 00 12.1	89 21 12.3
T. 6 S., R. 2 W., center sec. 18, southwest corner of 4 corners, northeast fence corner bears N. 45° 00′ W., 6 feet; iron post stamped "Prim. Trav. Sta. No. 35, 1906"	38 00 12.2	89 21 47.1
T. 6 S., R. 2 and 3 W., quarter corner on township line between sec. 13 and 18	38 00 12.7	89 22 20.3
T. 6 S., R. 3 W., quarter corner between secs. 13 and 14, T road south	38 00 15.2	89 23 26.1
Secs. 17 and 18, quarter corner between	38 00 16.8	89 25 39.3
T. 6 S., R. 3 W., sec. 17, center of; T road north	38 00 17.0	89 27 18.5
T. 6 S., R. 3 W., stone quarter corner between secs. 17 and 18, 18 feet to closing corner	38 00 17.5	89 27 51.4

Declination, south border of quadrangle, E. 5° 20′.

Carbondale Quadrangle.

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 9 S., R. 1 W., secs. 17, 18, 19 and 20, T road north	37 43 51.3	89 14 45.9
Carbondale, at northwest corner of I. C. R. R. park, 12 feet east of iron water stand, 2 feet east of iron fence, 6 feet south of iron fence, iron post stamped "Prim. Trav. Sta. No. 30, 1906"	37 43 43.6	89 12 59.4
Carbondale, corner Spring and Oak Sts., 30 feet north to north cross walk, 25 feet west to west sidewalk	37 43 45.3	89 13 28.0
Elbow corner, road south and west	37 43 45.5	89 11 58.8
Three corners, road south	37 43 39.1	89 11 04.5
T. 9 S., R. 1 W., approx. center of S. W. quarter sec. 13; 3 corners, road south	37 44 05.0	89 09 56.0
T. 9 S., R. 1 E. and 1 W., secs. 18 and 13, respectively, at middle south half of sec. line between, Jackson-Williamson county line	37 44 05.1	89 09 05.5
T. 9 S., R. 1 E., corner secs. 7 and 18, stone post, corner Jackson-Williamson county line; road east to Carterville	37 44 47.5	89 09 05.0

Carlyle Quadrangle—Bond and Clinton Counties.—The following geographic positions on U. S. Standard datum were determined by primary traverse run in July, 1907, by Mr. J. R. Ellis, assistant topographer. The line starts from an adjusted position on the Breese quadrangle 1.25 miles southwest of Bartelso, and follows highways near south edge of Carlyle quadrangle to Boulder thence northwest along highways to Keyesport thence westerly along highways near north edge of quadrangle to primary traverse station No. 23, 1905, at Jamestown. A tie was also obtained at Geoffrey triangulation station, U. S. Coast and Geodetic Survey.

Carlyle Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.	Longitude.
Bartelso, 1.25 miles southwest of; at T road north, in southeast corner of field owned by Herman Soole; nail in blaze on tree bears north 76° 45′ E., distant 39.8 feet; iron post stamped "Prim. Trav. Sta. No. 25, 1905"	° ′ ″ 38 31 44.8	° ′ ″ 89 29 02.8
Bartelso, 0.5 mile southeast of; crossroads, 33 feet southwest to corner fence post, 15 feet east to northwest corner small bridge	38 31 45.1	89 28 00.1
Stone quarter corner at crossroads	38 31 44.4	89 26 45.0
T. 1 N., R. 3 W., corner secs. 8, 9, 16 and 17, T road south, 35 feet west to corner fencepost	38 32 10.9	89 26 45.1
Geoffrey triangulation station; a Coast survey station in Santa Fe township, near center of N. E. quarter of N. E. quarter sec. 8. R. 3 W., T. 1 N. Station mark: Earthenware pyramid 6 by 6," marked U. S. C. S., placed 33 inches below surface, above which is a marble post 30 inches long, 6 inches square, marked U. | S. C. & G. | S. its upper surface even with the ground. Reference marks: Marble posts 32 inches long, 4 inches square, marked $\boxed{\times}$ placed east and north of line of fence bordering the road, their upper surfaces 2 inches above level of ground. To N. reference mark from station, 474.0 feet; to east reference mark from station, 714.7 feet. "Parkinson," north reference mark, 50° 24′ Parkinson east reference mark, 138° 52″. In 1882 the north reference mark was moved 9.4 feet west	38 32 58.2	89 26 55.0

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE—*Continued.*

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Stone quarter corner, crossroads	38	31	44.2	89	26	44.8
T. 1 N., R. 3 W., quarter corner between secs. 15 and 16, ditch north	38	31	43.9	89	25	38.1
T. 1 N., R. 3 W., stone quarter corner between secs. 14 and 15	38	31	45.2	89	24	30.0
Stable of Henry Waelz, southwest of; at point where roads from ferry across Kaskaskia river make a turn at top of hill, iron post at corner, stamped "Prim. Trav. Sta. No. 1, 1907 Illinois"	38	31	09.6	89	22	53.6
Waelz, 1 mile east of; T road west	38	30	53.2	89	21	43.8
T road south at old frame house	38	31	45.8	89	21	26.3
Posey, 0.5 mile south of; crossroads, 40 feet northwest to Osage orange tree, 30 feet southeast to telephone pole	38	31	46.1	89	21	09.5
Posey, 0.5 mile south and ⅝ mile east of intersection of crossroads	38	31	46.6	89	20	19.2
T. 1 N., R. 2 W., corner sections 15, 16, 21 and 22, at turn of road	38	31	21.4	89	18	37.5
Crossroads at schoolhouse	38	31	35.2	89	16	57.0
Hoffman, 0.75 mile south of; on east side of T road west, 15 feet west and 6 feet south to stone at T road west, iron post stamped "Prim. Trav. Sta. No. 2, 1907, ILLINOIS"	38	31	49.0	89	15	49.1
Hoffman, at southwest corner of L. Hussman's store, iron post stamped "Prim. Trav. Sta. No. 3, 1907 ILLINOIS"	38	32	29.1	89	15	48.0
T. 1 N., 2 W., quarter corner between sections 1 and 12, center of intersection of crossroads	38	33	07.8	89	15	47.9
T. 1 and 2 N., R. 2 W., quarter corner between sections 1 and 36, T road south, 24 feet north to corner of fence post	38	34	00.1	89	15	47.4
Hoffman, 1.75 miles north of; T. 1 and 2 N., R. 2 W., quarter corner between sections 1 and 36, iron post stamped "Prim. Trav. Sta. No. 4. 1907"	38	34	00.3	89	15	47.2
T. 1 and 2 N., R. 1 and 2 W., corner sections 1, 6, 31 and 36, crossroads, 20 feet south to center of small bridge	38	34	00.4	89	15	13.6
T. 2 N., R. 1 W., corner sections 31 and 32, T road north, 40 feet north to center of small bridge	38	33	56.9	89	14	03.9
T. 2 N., R. 1 W., corner sections 29, 30, 31 and 32, T road west, 44 feet south to center of small bridge	38	34	49.5	89	14	02.3
T. 2 N., R. 1 W., corner sections 19, 20, 29 and 30, crossroads	38	35	41.8	89	14	01.2
Ferren, Baltimore and Ohio Railroad crossing	38	36	25.1	89	13	59.8
T. 2 N., R. 1 W., corner sections 7, 8, 17 and 18, crossroads	38	37	26.7	89	13	58.2
Ferren, 2 miles north of; at northwest corner of crossroads at corner sections 5, 6, 7 and 8, T. 2 N., R. 1 W., iron post stamped "Prim. Trav. Sta. No. 5, 1907, ILLINOIS"	38	38	19.2	89	13	57.3
T. 3 N., R. 1 W., south corner sections 31 and 32, T road north	38	39	11.3	89	13	55.6
T. 2 N., R. 1 W., north corner sections 5 and 6, T. road south	38	39	11.3	89	13	56.5
T. 3 N., R. 1 W., corner sections 29, 30, 31 and 32, T road south, 10 feet east to center of bridge,	38	40	04.0	89	13	54.8
T. 3 N., R. 1 W., quarter corner between sections 20 and 29 crossroads.	38	40	56.7	89	13	22.5
Boulder, T road north in northeast part of	38	41	49.6	89	13	21.8
T. 3 N., R. 1 W., quarter corner between sections 8 and 17, T road west	38	42	42.4	89	13	21.3
T. 3 N., R. 1 W., corner sections 5, 6, 7 and 8, 15 feet northeast to corner fence post	38	43	36.3	89	13	54.2
Keyesport, 0.5 mile south of; Chicago, Burlington and Quincy railroad crossing	38	44	12.7	89	16	05.7
Railroad crossing Chicago, Burlington and Quincy railroad, on Clinton and Bond county line	38	44	31.6	89	16	28.4
Keyesport, 1.5 miles north of; on north side of wagon road and 56 feet west of west rail of C., B. & Q. R. R. at road crossing, iron post stamped "Prim. Trav. Sta. No. 6, 1907, ILLINOIS"	38	45	24.0	89	17	00.5
T. 4 N., R. 2 W., corner sections 26, 27, 34 and 35, crossroads, 15 feet south to center of small bridge	38	45	23.5	89	17	30.5
T. 4 N., R. 2 W., corner sections 27, 28, 33 and 34, T lane south	38	45	23.0	89	18	37.2
Crossroads, about 0.25 mile east of; corner of sections 28, 29, 32 and 33, 20 feet south to center of bridge	38	45	22.6	89	19	28.4
T. 4 N., R. 2 W., large stone at south corner of sections 32 and 33, T road west	38	44	29.8	89	19	38.3
T. 3 N., R. 2 W., north corner sections 4 and 5, T road south, county line	38	44	29.8	89	19	45.5
Crossroads, 20 feet north to milk platform	38	44	29.2	89	20	34.8
T. 3 and 4 N., R. 2 and 3 W., northwest corner sections 1, 6, 31 and 36, corner bears 30′ E., and 25 feet south of post, iron post stamped "Prim. Trav. Sta. No. 7, 1907, ILLINOIS"	38	44	28.6	89	22	18.8
T. 3 N., R. 3 W., north corner sections 1 and 2, T road south, 15 feet north to mulberry tree	38	44	27.8	89	23	25.4
T. 3 N., R. 3 W., sections 3 and 4, 40 feet west to north corner of and 20 feet north; at southeast corner of crossroads, 20 feet north and 10 feet west to south corner sections 33 and 34, T. 4 N., R. 3 W., T road north; T road south, 21 feet west to corner fence post, iron post stamped "Prim. Trav. Sta. No. 8, 1907, ILLINOIS"	38	44	26.9	89	25	40.2

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE—*Concluded.*

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 4 N., R. 3 W., south corner sections 33 and 34, T road north	38	44	27.1	89	25	40.3
T. 3 N., R. 3 W., north corner sections 3 and 4, T road south	38	44	27.1	89	25	40.7
T. 4 N., R. 3 W., south corner sections 32 and 33, 15 feet north to mail boxes	38	44	26.8	89	26	47.4
T. 3 N., R. 3 W., north corner sections 4 and 5, T road south, 13 feet north to hedge tree	38	44	26.8	89	26	48.0
T. 3 and 4 N., R. 3 W., south corner sections 5, 6, 31 and 32, on north side of county line road at T road south, corner of section is 20 feet south of post, iron post stamped "Prim. Trav. Sta. No. 9, 1907, ILLINOIS"	38	44	26.7	89	27	54.9
T. 3 and 4 N., R. 3 W., corner sections 5, 6, 31 and 32	38	44	26.5	89	27	54.9
T. 3 and 4 N., R. 3 and 4 W., corner sections 1, 6, 31 and 36, T. road E., 20 feet west to stone at corner of fence	38	44	25.9	89	28	54.9
Jamestown public school grounds, near south line of; 57 feet east of southwest corner, southwest corner of school building bears N. 5° E., 144 feet; in top of dressed limestone 5″ x 5″ x 24″, aluminum tablet stamped "Prim. Trav. Sta. No. 23, 1905"	38	43	59.7	89	31	06.9

Declination south edge, 4° 06′ E.
Declination east edge, 4° 54′ E.
Declination north edge, 4° 28′ E.

Hardinville Quadrangle—Crawford, Jasper, Lawrence and Richland Counties.—The following geographic positions were determined by primary traverse run in July 1907, by Mr. J. R. Ellis, assistant topographer. The line starts from Claremont triangulation station and follows highways along south and east edges of quadrangle to Robinson, thence westerly along the Illinois Central Railroad to Oblong triangulation station, thence westerly along railroad to Willow Hill, thence southerly along railroad and highways on west edge of quadrangle to Claremont triangulation station:

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Claremont triangulation station of the U. S. Lake Survey and U. S. C. & G. S., in section 29, T. 4 N., R. 14 W., German township, 3 miles northwesterly from town of Claremont a station on Ohio and Mississippi Railroad, on land of Brinkley heirs. Station mark: Two stone posts, one above the other in the usual manner. Reference marks· One north 67° 33′ west, distant 23.1 meters. One north 0° 39′ west, distant 7.8 meters. One north 71° 45′ east, distant 24.6 meters from station mark. Northwest corner of section 29 bears north 60° 03′ west, distant 847 meters from station mark	38	45	28.5	87	59	40.8
T. 4 N., R. 14 W., corner sections 28, 29, 32 and 33, 20 feet south to corner fence post	38	44	49.1	87	59	03.2
T. 4 N., R. 14 W., corner sections 27, 28, 33 and 34, T road west at school house, 10 feet east to rail fence	38	44	48.8	87	57	55.4
T. 4 N., R. 14 W., quarter corner between sections 26 and 27, crossroads, 15 feet north to center of bridge	38	45	15.1	87	56	47.2
T. 4 N., R. 14 E., quarter corner between sections 25 and 26, center of crossroads	38	45	14.9	87	55	39.3
T. 4 N., R. 13 and 14 W., quarter corner between sections 25 and 30, center of crossroads, Richland and Lawrence county line	38	45	14.7	87	54	31.4
Sumner, 2.25 miles north by 0.25 mile west of; on west side of road at T road east, 2 feet west to fence, 25 feet east to center of T road east, in top of concrete block 8 x 8 x 20″ in ground, aluminum tablet stamped "Prim. Trav. Sta. No. 10, 1907, ILLINOIS"	38	44	47.8	87	51	58.4
T. 4 N., R. 13 W., corner sections 27, 28, 33 and 34, 25 feet south to corner fence post	38	44	47.7	87	51	06.9

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.—*Concluded.*

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 4 N., R. 13 W., east corner sections 27 and 34, stone, T road west at church	38	44	47.5	87	49	58.9
T. 4 N., R. 13 W., corner sections 25, 26, 35 and 36, center of T road south	38	44	44.0	87	48	55.7
T. 4 N., R. 12 and 13 W., corner sections 25, 30, 31 and 36, crossroads, 10 feet west to center of small bridge	38	44	43.8	87	47	48.1
T. 4 N., R. 12 W., stone corner sections 29, 30, 31 and 32, T road south	38	44	44.8	87	46	42.8
Westport, 5.75 miles due south of; on east side of T road west at Fairview church, in top of concrete block 8 x 8 x 20″ inches, aluminum tablet stamped "Prim. Trav. Sta. No. 11, 1907, ILLINOIS"	38	44	46.0	87	45	35.3
T. 4 N., R. 12 W., corner sections 28, 29, 32 and 33, center of T road west	38	44	45.9	87	45	35.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 4 N., R. 12 W., corner sections 20, 21, 28 and 29. T road west	38	45	39.2	87	45	35.4
T. 4 N., R. 12 W., stone corner sections 16, 17, 20 and 21, fence east and west	38	46	32.2	87	45	35.4
Center of T road east	38	46	44.2	87	46	38.5
T. 4 N., R. 12 W., corner sections 7, 8, 17, and 18, center of crossroads	38	47	23.4	87	46	41.8
Westport, 0.75 mile east of; intersection at T road west	38	49	40.2	87	44	42.8
T. 5 N., R. 12 W., corner sections 21, 22, 27 and 28, center of county line road at north and south fence	38	51	00.0	87	44	26.0
Crawford, 1 mile north of; Lawrence county line	38	51	54.8	87	43	52.1
T road east, southeast corner, 7 feet north and 4 feet west to maple tree, 35 feet north and 20 feet west to center of T road east, in concrete block, aluminum tablet stamped "Prim. Trav. Sta. No. 12, 1907, ILLINOIS"	38	52	57.9	87	43	52.7
Quarter corner between sections ————, center of crossroads	38	53	40.5	87	43	53.1
T. 5 and 6 N., R. 12 W., corner sections 3, 4, 33 and 34, stone, 1,340 feet east of; T road east on T. S. line	38	54	41.6	87	44	10.4
T. 6 N., R.12 W., corner sections 27, 28, 33 and 34, T road west, 25 feet due east to corner fence post	38	55	34.0	87	44	27.5
Road west at Indian boundary	38	56	19.8	87	44	51.8
New Hebron, T road just northeast of; 10 feet northeast to large black oak tree	38	57	13.1	87	44	35.8
Lane east at turn of road	38	58	19.1	87	44	30.2
T. 6 N., R. 12 W., corner sections 3, 4, 9 and 10, T road west at school house, 12 feet east to corner yard fence	38	58	59.3	87	44	19.2
T. 6 N., R. 12 W., north corner sections 3 and 4, center of T road south, just east of entrance to Robinson Fair Grounds	38	59	54.5	87	44	19.8
Robinson court house, in stone post at south entrance to grounds, aluminum tablet stamped "Prim. Trav. Sta. No. 13, 1907, ILLINOIS"	39	00	18.2	87	44	21.6

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD, ROBINSON TO STE. MARIE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Robinson, 2 miles west of; north and south road crossing on section line	39	00	05.5	87	46	37.2
Range line road crossing	39	00	08.7	87	47	47.0
T. 5 and 6 N., R. 12 and 13 W., corner sections 1, 6, 31 and 36, center of road at picket fence east at corner of orchard	38	59	51.3	87	47	46.7
North and south road crossing at mile post No. 43	39	00	04.5	87	48	37.5
Stoy railroad station, road crossing	38	59	45.9	87	49	59.7
Oblong triangulation station, in southeast quarter of southeast quarter of section 32, T. 7 N., R. 13 W., height of station 100 feet. Station mark: A stone post below surface with another over it as a surface mark. Reference mark: Three stone posts, one S. 44° 15′ W., distant 125.7 meters; one S. 78° 32′ W., distant 90 meters, and one N., 65° 13′ W., distant 97.7 meters. Southeast corner section 32 is S. 73° 42′ E., distant 325.6 meters. Ground at station is 500 feet above mean sea level, (approx.)	38	59	54.4	87	52	29.8
Oblong, range line road crossing, 550 feet south of crossing is corner sections 1, 6, 31 and 36, T. 5 and 6 N., R. 13 and 14 W	38	59	56.7	87	54	31.5
Oblong, 1 mile west of; north and south road crossing	39	00	01.6	87	55	38.7
Oblong, 1.70 miles west of; Oblong and Willow Hill road crossing	39	00	04.2	87	56	20.3
Willow Hill, 3 miles east of; north and south road crossing	38	59	56.8	87	57	52.7
Willow Hill, 2 miles east of, road crossing	38	59	57.1	87	58	59.9
Willow Hill, 1 mile east of; north and south road crossing	38	59	57.5	88	00	06.9
Willow Hill, northwest corner of brick foundation of J. E. Jones grain elevator, aluminum tablet stamped "Prim. Trav. Sta. No. 14, 1907, ILLINOIS"	38	59	57.4	88	01	15.2
East and west street crossing	38	59	44.8	88	01	15.4
T. 6 and 7 N., R. 14 W., and franctional range 11 E., corner sections 6, 6, 31 and 31, cross streets just west of township house	38	59	44.8	88	01	19.4
East and west road crossing, 770 feet south of milepost 17	38	58	00.2	88	01	13.0
Road crossing 500 feet north of mile post 16	38	57	20.6	88	01	13.2
Ste. Marie Station, road crossing 490 feet south of	38	55	57.7	88	01	32.4

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 5 and 6 N., fractional range 11 E., corner sections 6 and 31, at corner of house	38	54	31.4	87	02	16.6
T. 5 N., fractional R. 10 and 11 E., center of crossroads	38	53	38.5	87	02	17.1
T. 5 N., fractional R. 11 E., west corner sections 7 and 18, T road east.	38	52	46.2	88	02	17.3
T. 5 N., fractional R. 11 E., east corner sections 12 and 13, T road west	38	52	45.6	88	02	17.3
T. 5 N., fractional R. 11 E., west corner sections 18 and 19, T road east	38	51	51.8	88	02	17.6
Olney East Base, T. 5 N., fractional R. 11 E., 3.5 miles east and 0.5 mile north of West Liberty railroad station	38	51	44.1	88	01	35.1
T. 5 N., R. 14 W., west corner sections 19 and 30, Richland and Jasper county line	38	50	59.5	88	01	23.8
T. 5 N., fractional R. 11 E., east corner sections 19 and 30, county line	38	50	59.0	88	01	23.8
T. 5 N., R. 14 W., west corner sections 30 and 31, center T road east	38	50	06.6	88	01	24.2
T road south at Jos. Holmes mail box	38	49	26.3	88	00	52.9
T. 4 N., R. 14 W., corner sections 5, 6, 7 and 8, stone, crossroads at school house	38	48	21.1	88	00	10.7
T. 4 N., R. 14 W., south corner sections 7 and 8, T road north	38	47	28.3	88	00	10.9
T. 4 N., R. 14 W., north corner sections 17 and 18, T road south	38	47	28.3	88	00	09.8
Stone at T road north at school house	38	46	35.4	88	00	11.1
Claremont triangulation station	38	45	28.5	87	59	40.8

Magnetic declination, south border, 3° 42′ E.
Magnetic declination, east border, 3° 36′ E.
Magnetic declination, west border, 3° 36′ E.

Okawville Quadrangle—St. Clair and Washington Counties.—The following geographic positions on U. S. Standard datum were determined by Mr. J. R. Ellis, assistant topographer, by primary traverse run in 1907. The line starts at a point located near S. W. corner of Carlyle quadrangle and follows highways near east, south and west borders of quadrangle and is tied to a point located near southeast corner of Belleville quadrangle:

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Center of T road east	38	31	18.2	89	26	44.7
T road west, corner sections, 20 feet west to center of small bridge	38	30	25.5	89	26	44.0
Kaskaskia River, center of bridge over	38	29	22.7	89	26	26.3
Stone, quarter corner between sections, crossroads	38	28	41.0	89	26	10.2
Covington, T. 1 S., R. 3 W., southeast corner of northeast quarter of southwest quarter section 9, T road west, 30 feet west to center of triangular grass plot	38	27	08.0	89	26	10.2
T. 1 S., R. 3 W., southeast corner northeast quarter of northwest quarter section 11, 1.75 miles west of Covington; stone at T road east	38	27	09.2	89	28	06.2
Pecan Grove Creamery, T. 1 S., R. 3 W., center section 18, T road north, 35 feet northwest to corner fence post, 35 feet northeast to hitch rack	38	26	29.8	89	28	06.5
T. 2 S., R. 4 W., northeast corner section 24; 10 feet south to northwest corner of ridge	38	26	04.2	89	28	39.6
T road west, corner section 25, (N.E. corner), T. 2S., R. 4 W	38	25	11.7	89	28	39.0
T. 1 S, R. 4 W., northeast corner of southeast quarter of northwest quarter of section 36; 0.75 mile north of Addieville; at southwest corner of T road west, iron post stamped "Prim. Trav. Sta. No. 15, 1907, ILLINOIS"	38	24	06.6	89	29	11.1
T. 2 S., R. 3 W., and 4 W., center of T road south, corner sections 7 12, 13 and 18	38	21	42.2	89	28	36.1
T. 2 S., R. 3 and 4 W., corner sections 19, 24, 25 and 30, center of crossroads	38	19	57.7	89	28	36.9
T. 2 S., R. 3 and 4 W., south corner sections 31 and 36	38	18	12.9	89	28	38.7
T. 3 S., R. 3 and 4 W., corner sections1, 6 7 and 8, T road north, 27 feet east to center of small bridge	38	17	20.7	89	28	39.6
T. 3 S., R. 4 W., northwest corner of northeast quarter section 13, 500 feet south of; road crossing north and south on Illinois Southern R. R., 0.75 mile south of water tank	38	16	24.2	89	29	13.5
Oakdale station, on north side of road and 21 feet west of road crossing Illinois Southern R. R., iron post stamped "Prim. Trav. Sta. No. 16, 1907, ILLINOIS", 10 feet northeast to warning post	38	15	45.6	89	29	47.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Oakdale station, 1.7 miles southwest of road crossing north and south.	38	14	51.8	89	31	12.0
(LEAVE RAILROAD AND FOLLOW HIGHWAYS.)						
T. road west, 15 feet east to corner fence post	38	15	02.7	89	31	45.4
T. 3 S., R. 4 W., northwest corner southwest quarter of southwest quarter section 21, 2.75 miles west of Oakdale, 0.75 mile south of T road east	38	15	04.6	89	33	09.0
T. 3 S., R. 4 W., northwest corner of southeast quarter of northwest quarter section 20; turn of road, gas pipe	38	15	32.4	89	33	59.0
T. 3 S., R. 4 and 5 W., corner sections 19, 24, 25 and 30, center of T road west	38	14	54.0	89	35	33.3
T. 3 S., R. 5 W., in northeast corner section 26, at crossroads, iron post stamped "Prim. Trav. Sta. No. 17, 1907, ILLINOIS"	38	14	53.0	89	36	38.4
T. 3 S., R. 5 W., corner sections 23, 24, 25 and 26, stone	38	14	53.1	89	36	38.8
T. 3 S., R. 5 W., corner sections 22, 23, 26 and 27, center of T road north	38	14	54.0	89	37	44.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE—*Concluded.*

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 3 S., R. 5 W., corner sections 21, 22, 27 and 28, center of T road at fence north and south	38 14 54.4	89 38 50.6
T. 3 S., R. 5 W., corner sections 20, 21, 28 and 29, crossroads, 15 feet south to center of bridge	38 14 54.9	89 39 56.4
T. 3 S., R. 5 W., corner sections 19, 20, 29 and 30, center of crossroads	38 14 54.6	89 41 03.3
T. 3 S., R. 5 W., west corner sections 19 and 30, Washington and St. Clair county line	38 14 54.2	89 42 11.3
T. 3 S., R. 6 W., east corner sections 24 and 25, center of T road west	38 14 55.9	89 42 11.3
T. 3 S., R. 6 W., southeast corner section 24; 35 feet southwest to corner sections 23, 24, 25 and 26, T. 3 S., R. 6 W., 7 feet northeast to corner of fence post, iron post stamped "Prim. Trav. Sta. No. 18, 1907, ILLINOIS"	38 14 57.1	89 43 16.6

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 3 S., R. 6 W., northwest corner of southwest quarter of northwest quarter section 13; Oak Grove saloon, T road east, 13 feet east to center of bridge	38 16 30.4	89 43 18.1
T. 3 S., R. 6 W., northwest quarter of section 12, roads northwest and southeast, at road south	38 17 34.4	39 43 18.2
T. 3 S., R. 6 W., corner sections 1, 2, 11 and 12	38 17 43.2	89 43 18.2
T. 3 S., R. 6 W., quarter corner at north side of section 2	38 18 20.6	89 43 52.2
T. 2 S., R. 6 W., quarter corner at south side of section 35	38 18 20.6	89 43 52.9
T. 2 S., R. 6 W., quarter corner between sections 26 and 35, Dormostrandt, center of crossroads	38 19 14.4	89 43 53.3
T. 2 S., R. 6 W., corner sections 22, 23, 26 and 27, at turn of road	38 20 08.8	89 44 26.7
T. 2 S., R. 6 W., northeast corner of northwest quarter of northeast quarter section 22; Little Muddy Creek, center of bridge over	38 21 02.6	89 44 43.2
T. 2 S., R. 6 W., southeast corner northwest quarter of northeast quarter section 10; 2.5 miles east of Fayetteville; in southeast corner of brick foundation of school house, aluminum tablet stamped "Prim. Trav. Sta. No. 19, 1907, ILLINOIS"	38 22 38.8	89 44 52.4
T. 2 S., R. 6 W., near southwest corner of southwest quarter of northwest quarter of section 12; 1 mile northwest of St. Libory, T road north	38 22 26.7	89 43 20.6
T. 2 S., R. 6 W., northwest corner section 1	38 23 34.6	89 43 20.1
T. 1 and 2 S., R. 5 and 6 W., corner sections 1, 6, 31 and 36, T road west to corner of bridge ,St. Clair and Washington County line	38 23 34.0	89 42 14.2
T. 2 S., R. 5 W., south corner sections 5 and 6, center of T road north at school	38 23 33.8	89 41 07.1
T. 2 S., R. 5 W., corner sections 4, 5, 32 and 33, T road north, 15 feet west to center of bridge	38 23 34.2	89 40 00.7
T. 2 S., R. 5 W., corner sections 3, 4, 34 and 35, crossroads	38 23 34.6	89 38 54.2
T. 2 S., R. 5 W., stone corner sections 22, 23, 26 and 27, at turn of road just south of crossroads	38 25 20.4	89 37 48.4
T. 2 S., R. 5 W., southwest corner of northwest quarter section 22; New Memphis and Nashville road at road east to Walnut	38 25 59.5	89 38 34.4
Wittenburg, center of bridge over Kaskaskia river	38 26 42.9	89 39 49.4
New Memphis station, Louisville and Nashville railroad crossing, 640 feet west of	38 27 29.0	89 40 36.6
North and south road crossing	38 27 36.0	89 41 09.3
Corner sections	38 27 30.3	89 41 09.3
Road crossing north and south, line between Clinton and St. Clair counties	38 27 50.0	89 42 15.8
T. 1 N., R. 6 W., quarter corner south side of section 35, stone at T road north	38 28 50.1	89 43 56.4
T. 1 N., R. 6 W., southwest corner of northwest quarter of northwest quarter section 35; quarter corner between sections, center of crossroads	38 29 42.6	89 43 56.8
North and south road crossing of Southern Railroad near southwest corner of field of J. B. Freese, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	38 31 55.6	89 45 38.9

Magnetic declination, east border of quadrangle 4° 31′ E.
Magnetic declination, south border of quadrangle, 5° 13′ E.
Magnetic declination, west border of quadrangle, 5° 22′ E.

Baldwin and New Athens Quadrangles—St. Clair County.—The following geographic positions were obtained in 1907 by primary traverse run by Mr. J. R. Ellis, topographic aid. The line starts from adjusted position of bench mark 18, 1907, near Marissa and follows county roads west and north borders of quadrangle to bench mark 15, 1905 at Belleville:

BALDWIN QUADRANGLE.

ST. CLAIR COUNTY.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. road north, stone	38	14	44.0	89	44	07.0
North Marissa, T road east	38	15	20.4	89	45	13.9
T. 3 S., R. 7 W., sections 20, 21, 28 and 29, corner of, center of east and west road at hedge fence north	38	14	57.8	89	46	37.3
Marissa station, 0.33 mile northwest of; east and west road crossing Illinois Central railroad	38	14	57.5	89	45	35.0
T. 3 S., R. 7 W., corner sections 19, 20, 29 and 30, crossroads, 15 feet west to center of bridge	38	14	58.1	89	47	43.6
T. 3 S., R. 7 W., west corner sections 19 and 30, 5 feet south to hedge tree	38	14	57.4	89	48	56.0
Doza Creek, center of iron bridge over	38	14	56.9	89	50	36.5
T. 3 S., R. 8 W., quarter corner between sections 27 and 28, T road north	38	14	37.6	89	58	48.1
T. 3 S., R. 8 W., near quarter corner sections 26 and 27, in the northwest corner of crossroads, about 2 miles north of Redbud, iron post stamped "Prim. Trav. Sta. No. 21, 1907, ILLINOIS" 20 feet east and 27 feet south to quarter corner stone	38	14	39.0	89	59	54.8

Declination north border of quadrangle 4° 56′ East.

NEW ATHENS QUADRANGLE.

ST. CLAIR COUNTY.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 3 S., R. 7 W., section 22, at center of; set in southeast corner of intersection of crossroads, 25 feet west and 6 feet north to center of crossroads, 6 feet southwest to nail in blaze on white oak tree, iron post stamped "Prim. Trav. Sta. No. 20, 1907"	38	15	24.3	89	51	42.2
T. 3 S., R. 7 W., quarter corner between sections 15 and 22	38	15	50.6	89	51	42.7
Dutch Hill, 0.75 mile west and 0.5 mile south of; T road east, 22 feet due west to center of gate	38	16	29.6	89	51	42.8
T. 3 S., R. 7 W., quarter corner between sections 3 and 10, center of crossroads	38	17	35.5	89	51	43.2
New Athens, 0.5 mile southeast of; forks of road, cross on telephone pole	38	19	02.4	89	52	16.8
New Athens, Kaskaskia river, center of wagon bridge over	38	19	45.0	89	52	45.0
New Athens, 1.3 miles west of; stone at turn of road to south	38	19	42.0	89	54	13.1
St. Clair-Monroe county line, 0.75 mile north of, T road west at Chas. Lindaur's mailbox	38	19	06.0	89	55	35.6
St. Clair-Monroe county line, center of north and south road, 25 feet north to south side of straw stack	38	18	28.6	89	55	27.8
Hecker, about 3 miles east of; T road south at George Vogler's mailbox.	38	18	10.2	89	56	16.5
T. 3 S., R. 8 W., stone corner of sections 11, 12, 13 and 14	38	16	45.2	89	56	37.8
T. 3 S., R. 8 W., corner secs. 13, 14, 23 and 24; 20 feet due east of dead tree	38	15	53.5	89	56	37.4
T. 3 S., R. 8 W., center sec. 23, 0.25 mile south of; crossroads, south end of small bridge	38	15	12.2	89	57	09.2

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Hecker, 1.75 miles south of; T road west, 15 feet south to west end of bridge	38	16	49.1	89	59	38.7
Hecker, crossroads	38	18	18.8	89	59	39.1
T. 3 S., R. 8 W., stone at north corner secs. 4 and 5, St. Clair-Monroe county line	38	18	30.8	89	59	55.6
Hecker, 1 mile north of; T road east, 25 feet due west to pole at fence corner	38	19	22.6	89	59	41.5
Schoolhouse, just east of; T road west	38	20	41.3	89	59	41.2
Schoolhouse, 0.8 mile north of; T road west	38	21	20.8	89	59	40.9
West Fork, center of bridge over	38	22	11.6	89	59	43.3
T. 2 S., R. 8 W., near stone quarter corner between secs. 4 and 9, 2 miles south of Smithton, northeast corner of T road east, 15 feet south and 5 feet west to quarter corner stone, iron post stamped "Prim. Trav. Sta. No. 22, 1907"	38	22	52.7	89	59	23.9
T. 1 and 2 S., line between center of road at fence east	38	23	45.4	89	59	28.2
Smithton, in north part of; T street south; 30 feet west and 12 feet south to lamp post	38	24	37.0	89	59	31.0
Douglas, T road east; 33 feet due west to small gate	38	25	29.0	89	58	56.1
T. 1 S., R. 8 W., secs. 15, 16, 21 and 22, corner of; center of road at fence east and west	38	26	21.0	89	58	58.4
T. 1 S., R. 8 W., secs. 3, 4, 9 and 10, corner of; center of road at fence east and west	38	28	05.0	89	58	59.1
T. 1 S., R. 8 W., stone at south corner secs. 33 and 34	38	28	59.6	89	59	00.5
T. 1 N., R. 8 W., corner secs. 27, 28, 33 and 34	38	29	51.9	89	59	00.4

Declination south border of quadrangle 4° 56′ East.
Declination west border of quadrangle 5° 18′ East.

Hennepin, Lacon, LaSalle, Wenona and Wyonet Quadrangles—Bureau, LaSalle and Putnam Counties.—The following geographic positions upon U. S. Standard datum were determined from primary traverse run by C. B. Kendall, assistant topographer in 1908. The line begins with adjusted position of the Illinois River Survey triangulation station Utica and follows highways north to Triumph, thence west to northwest corner of LaSalle quadrangle, 1.25 miles north of Arlington, thence south via Arlington to Marquette where it is tied to Illinois River Survey triangulation station All Forks, thence south along the Indiana, Illinois and Iowa Railroad to a point about one mile north of Marks, and continues south along highways via Marks to Granville, thence east via Ticona to Lowell where it turns north and is tied to Utica triangulation station, the beginning.

For the control of the Hennepin quadrangle, the line begins 1.25 miles north to Arlington and follows highways west via Grader and Limerick to the northwest corner of quadrangle, thence south via Tuskilwa to the southwest corner of quadrangle, thence east to Hennepin where it is tied to the Illinois River Survey triangulation station ravine, and continues east and is tied to adjusted position at Granville.

LaSalle Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Utica triangulation station, U. S. A. engineers; marked by stone and pipe, on top of sandstone bluff 0.5 mile east of Utica, 1,800 feet east of large dwelling house of Mrs. William Clark, 150 feet north and 2,000 feet east of milepost 94 on C. R. I. and P. Ry.; in southwest quarter sec. 9, T. 33 N., R. 2 E., Utica township	41	20	35.6	89	00	06.7
Utica, at north edge of, T road west, 35 ft. southeast to telegraph pole, 45 feet northwest to oak tree	41	20	47.1	89	00	43.4
T. 33 N., R. 2 E., quar. cor. between secs. 4 and 5, crossroads, center of intersection	41	21	39.5	89	00	36.2
T 33 N., R. 2 E., quar. cor. between secs. 4 and 5, 40 feet northwest of center of crossroads, at corner of fence, in southeast corner of northeast quarter sec. 5; iron post stamped "Prim. Trav. Sta. No. 8, 1908–Illinois"	41	21	39.8	89	00	36.6
T. 33 and 34 N., R. 2 E., corner secs. 4, 5, 32 and 33, T lane west; center of north and south road and east and west line between Utica and Waltham townships	41	22	05.6	89	00	35.9
T. 34 N., R. 2 E., cor. secs. 28, 29, 32 and 33, T road east, center of north and south road, 25 feet east to center of triangle	41	22	57.6	89	00	35.8
T. 34 N., R. 2 E., cor. secs. 20, 21, 28, 29, fences east and west, center of north and south road	41	23	49.8	89	00	36.1
T. 34 N., R. 2 E., cor. secs. 16, 17, 20 and 21, center of intersection of crossroads	41	24	42.1	89	00	36.6
T. 34 N., R. 2 E., cor. secs. 8, 9, 16 and 17, fences east and west, center of north and south road	41	25	34.5	89	00	37.3
T. 34 N., R. 2 E., cor. secs. 4, 5, 8, 9, second class T road east ,center of north and south road, 10 feet east to center of triangle	41	26	26.6	89	00	38.0
T. 34 N., R. 2 E., north cor.secs. 4 and 5, T road South, center of north edge of triangle, east and west line between Ophir and Waltham townships	41	27	18.7	89	00	39.2
T. 35 N., R. 2 E., south cor. secs. 32 and 33, T road north, center of east and west road, east and west line between Ophir and Waltham townships	41	27	18.7	89	00	41.0
T. 35 N., R. 2 E., cor. secs. 28, 29, 32 and 33, crossroads, stone in center of intersection	41	28	10.8	89	00	41.8
T. 35 N., R. 2 E., cor. secs. 20, 21,28 and 29, crossroads; center of intersection	41	29	03.0	89	00	42.7
T. 35 N., R. 2 E., cor. secs. 16, 17, 20 and 21, crossroads 0.5 mile east of Triumph, center of intersection, 50 feet northeast to large boulder at farm gate, 45 feet northwest to willow tree at corner of fence	41	29	54.8	89	00	44.0
Triumph, in concrete porch 1 foot from west wall at northwest corner of First National bank; aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1908, Illinois"	41	30	00.4	89	01	17.5
Triumph, at west edge of, T road south, center of east and west road, 20 feet south to center of triangle	41	29	55.6	89	01	48.5
T. 35 N., R. 2 E., cor. secs. 17, 18, 19 and 20 (?), at bend of road to north.	41	29	55.6	89	01	52.7
Vermilion river, center of bridge over	41	29	28.6	89	02	39.6
T. 35 N., R. 1 E., quar. cor. between secs. 23 and 24 (?), T road north 270 feet west of bridge over stream, center of east and west road, 25 feet northwest of center of triangle	41	29	30.7	89	03	32.6
T. 35 N., R. 1 E., quar. cor. between secs. 22 and 23, 0.25 mile east of, 4 corners at schoolhouse and church, center of crossroads	41	29	30.1	89	04	59.7
T. 35 N., R. 1 E., cor. secs. 14, 15, 22 and 23, second class T road south, fence north, center of east and west road	41	29	56.2	89	05	17.3
T. 35 N., R. 1 E., cor. secs. 15, 16, 21 and 22, center of crossroads	41	29	55.4	89	06	27.8
T. 35 N., R. 1 E., cor. secs. 16, 17, 20 and 21; center of crossroads	41	29	54.1	89	07	37.8
T. 35 N., R. 1 E., cor. secs. 16, 17, 20 and 21, 30 feet northwest of, at corner of hedge fence in northwest corner of crossroads and southeast corner of sec. 17; iron post stamped "Prim. Trav. Sta. No. 2, 1908, Illinois"	41	29	54.3	89	07	38.0
T. 35 N., R. 1 E., cor. secs. 17, 18, 19 and 20; center of crossroads	41	29	53.2	89	08	46.4
T. 35 N., R. 1 E., west corner of secs. 18 and 19, T road east, center of north and south road, 10 feet east to center of triangle, north and south line between LaSalle and Bureau counties and 3rd P. M.	41	29	52.3	89	09	58.6
T. 17 and 18 N., R. 11 E., east corner of secs. 1 and 36, T road west, center of north and south road, 15 feet west to center of triangle, north and south line between LaSalle and Bureau counties and 3rd P. M.	41	29	45.1	89	09	58.6
T. 17 N., R. 11 E., north cor. secs. 1 and 2, T road south, center of east and west road ,15 feet south to center of triangle	41	29	44.5	89	11	10.1
T. 17 N., R. 11 E., north quar. cor. secs. 3, T roads, center of east and west roads, 40 feet southeast to telephone pole, 35 feet north to yard fence	41	29	43.7	89	12	37.5
T. 18 N., R. 11 E., south cor. secs. 32 and 33, T road north, center of east and west road, 15 feet north to center of triangle	41	29	43.2	89	14	19.5
T. 17 N., R. 11 E., north cor. secs. 4 and 5, T road south, center of east and west road, 15 feet south to center of triangle	41	29	43.2	89	14	20.9

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 17 N., R. 11 E., north cor. of secs. 4 and 5, 76 feet southeast of, in center of schoolhouse (yard) in northwest corner of sec. 4; iron post stamped "Prim. Trav. Sta. No. 3, 1908, Illinois"	41	29	42.8	89	14	20.1
T. 17 N., R. 11 E., cor. secs. 4, 5, 8 and 9, crossroads, center of intersection	41	28	51.9	89	14	21.2
Arlington, main street crossing of Chicago, Burlington and Quincy railroad, center between main tracks	41	28	24.2	89	14	54.3
T. 17 N., R. 11 E., quar. cor. between secs. 16 and 17, crossroads, center of intersection	41	27	33.0	89	14	21.1
T. 17 N., R. 11 E., quar. cor. between secs. 20 and 21, crossroads, center of intersection	41	26	40.3	89	14	20.5
T. 17 N., R. 11 E., cor. secs. 28, 29, 32 and 33	41	25	21.3	89	14	19.0
Ottville, 0.8 mile southeast of, T road south, center of east and west road, 5 feet south to center of triangle	41	20	39.1	89	14	53.0
T. 16 N., R. 11 E., quar. cor. between secs. 29 and 32, T road west center of north and south road, 10 feet east to end of wire fence	41	20	06.5	89	14	52.5
Granville, 0.5 mile southwest of, T road north, T. 15 N., R. 11 E., quar. cor. between secs. 28 and 29 (?), 10 feet north to center of east and west road	41	15	27.0	89	14	25.6
Granville, at southeast edge of, crossroads 250 feet north of elevator and 500 feet south of T. M. & N. R. R. track, T. 15 N., R. 11 E., quar. cor. between secs. 27 and 28 (?)	41	15	27.3	89	13	16.6
T. 15 N., R. 11 E., quar. cor. between secs. 26 and 27 (?), 1.5 miles east of Granville, 500 feet east of T road north, T road south, center of east and west road, 15 feet south to center of triangle	41	15	28.0	84	12	07.1
T. 15 N., R. 11 E., quar. cor. between secs. 25 and 26, crossroads at standard corner, center of intersection, 35 feet southeast to corner of brick store, 50 feet north to railroad	41	15	28.3	89	10	56.6
T. 15 N., R. 11 E., east quar. cor. sec. 25 T road east on third principal meridian and line between LaSalle and Putnam counties, 15 feet west to center of triangle, 40 feet north to center of track	41	15	31.6	89	09	46.4
T. 32 N., R. 11 E., west corner between secs. 7 and 18, T road east on third principal meridian and line between LaSalle and Putnam counties, center of north and south road, 15 feet east to center of triangle	41	15	01.9	89	09	46.2
T. 32 N., R. 1 E., secs. 7, 8, 17 and 18, crossroads, center of intersection	41	15	01.9	89	08	42.6
T. 32 N., R. 1 E., cor. secs. 8, 9, 16 and 17, crossroads, center of intersection	41	15	02.4	89	07	32.6
T. 32 N., R. 1 E., cor. secs. 8, 9, 16, 17, crossroads, center of intersection, 50 feet southeast of, set by telephone pole at fence in southeast corner of intersection of crossroads and northwest corner of sec. 16; iron post stamped "Prim. Trav.Sta. No. 6, 1908, Illinois"	41	15	01.9	89	07	32.2
T. 32 N., R. 1 E., cor. secs. 9, 10, 15 and 16, T road south, center of east and west road, 15 feet south to center of triangle	41	15	02.1	89	06	22.7
T. 32 N., R. 1 E., cor. secs. 10, 11, 14 and 15, center of crossroads	41	15	01.8	89	05	12.4
T. 32 N., R. 1 E., cor. secs. 11, 12, 13 and 14, 700 feet west of, center of Illinois Central R. R. at crossing	41	15	01.6	89	04	13.4
T. 32 N., R. 1 E., cor. secs. 11, 12, 13 and 14, 2,200 feet east of, T road west, center of north and south road, 50 feet west to center of triangle	41	15	02.3	89	03	35.2
Lowell, 0.8 mile north of, T road east, center of north and south road, 10 feet east to center of triangle	41	15	35.2	89	00	44.8
T. 32 N., R. 2 E., quar. cor. between secs. 4 and 5, T road east, bend of north and south road to north, hickory tree in triangle	41	16	21.4	89	00	37.5
T. 32 N., R. 2 E., north cor. secs. 4 and 5, stone at bend of road east, east and west line Deer Park and Vermilion townships	41	16	48.2	89	00	37.4
T. 33 N., R. 2 E., south cor. secs. 32 and 33, stone at T road north, 25 feet north to center of triangle, east and west line between Deer Park and Vermilion townships	41	16	48.2	89	00	36.1
T. 33 N., R. 2 E., cor. secs. 28, 29, 32 and 33, T road east, center of north and south road, 25 feet southeast to center of triangle, 25 feet west to gate	41	17	40.6	89	00	36.0
T. 33 N., R. 2 E., cor. secs. 20, 21, 28 and 29, center of crossroads	41	18	33.1	89	00	36.2
T. 33 N., R. 2 E., cor. secs. 16, 17, 21 and 22, T road east at south end of approach to bridge over Illinois river at Utica, center of north and south road	41	19	34.7	89	00	35.6
Utica, south of, center of draw span of highway bridge over Illinois river	41	19	40.1	89	00	36.5
Utica, 30 feet east of station, center of track of Illinois Valley Electric railroad at street crossing	41	20	20.8	89	00	36.4
Utica, 50 feet west of, main street crossing Chicago, Rock Island & Pacific R. R., north rail of main track	41	20	34.4	89	00	32.7
Utica, Illinois River Survey station (Dupl.)	41	20	35.6	89	00	06.7

Magnetic declination of north border of quadrangle is 4° 15′ east.
Magnetic declination of west border of quadrangle is 4° 17′ east.
Magnetic declination of south border of quadrangle is 4° 13′ east.
Magnetic declination of east border of quadrangle is 4° 38′ east.

Wenona Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
Tonica, 1 mile northwest of, T. 32 N., R. 1 E., quar. cor. between secs. 13 and 24 (?), T road west, center of north and south road, 35 feet northwest to corner of fence, 25 feet east to gate	° ′ ″ 41 14 10.5	° ′ ″ 89 03 20.5
Tonica, 300 feet southeast of station, T road northwest, 25 feet northwest to center of triangle, 25 feet east to te ephone pole, 140 feet northeast to C. B. & Q. R. R crossing	41 13 25.7	89 03 07.8
Tonica, 1.25 miles northeast of station, T. 32 N., R. 2 E., near northeast corner of sec. 20, center of intersection, 25 feet west to telephone pole, 60 feet east to oak	41 14 07.4	89 02 10.8
Lowell, at south edge of, center of crossroads, T. 32 N., R. 2 E., one-sixteenth cor. sec. 17 (?)	41 14 49.7	89 00 37.7
Lowell, at south edge of, center of crossroads, T. 32 N., R. 2 E., in southeast corner of northeast quarter of sec. 17, in northwest corner intersection of crossroads, at corner of fence; iron post stamped "Prim. Trav. Sta. No. 7, 1908, Illinois"	41 14 49.9	89 00 38.0

Magnetic declination of north border of quadrangle is 4° 13′ east.

Hennepin Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
T. 17 N., R. 11 E , cor. secs. 29, 30, 31 and 32, about 300 feet east of, T road south, center of east and west road	° ′ ″ 41 25 20.9	° ′ ″ 89 15 24.3
T. 17 N., R. 11 E., south cor. secs. 31, and 32, T road north, center of east and west road, east and west line between Westfield and Hall townships	41 24 28.2	89 15 28.7
T. 16 N., R. 11 E., north corner secs. 5 and 6, T road south, center of east and west road, east and west line between Westfield and Hall townships	41 24 28.2	89 15 29.0
T. 16 N., R. 11 E., cor. secs. 5, 6, 7 and 8, center of crossroads	41 23 36.8	89 15 29.0
T. 16 N., R. 11 E., cor. secs. 7, 8, 17, 18, center of crossroads	41 22 44.1	89 15 28.6
T. 16 N., R. 11 E., cor. secs. 7, 8, 17 and 18, center of crossroads, 35 feet southwest of, in northeast corner of yard of Kline schoolhouse, northeast corner sec. 18; iron post stamped "Prim. Trav. Sta. No. 4, 1908, Illinois"	41 22 43.9	89 15 28.9
T. 16 N., R. 11 E., cor. secs. 17, 18, 19 and 20, center of crossroads	41 21 51.5	89 15 28.4
Ottville, forks of roads southwest and southeast, center of triangle	41 20 53.2	89 15 32.6
T. 16 N., R. 11 E., cor. secs. 29, 30, 31 and 32, stone in center of east and west road	41 20 06.3	89 15 27.9
Marquette station, just west of, road crossing Chicago, Rock Island & Pacific railroa , center between main tracks	41 19 31.6	89 15 53.9

GEOGRAPHIC POSITIONS ALONG THE INDIANA, ILLINOIS & IOW RAILROAD.

Stations.	Latitude.	Longitude.
Howe, just south of station, crossing of Illinois, Indiana & Iowa R. R. ov r the Chicago, Rock Island & Pacific railroad, center of girder bridge	° ′ ″ 41 19 33.1	° ′ ″ 89 16 59.4
All Fork creek triangulation station, U. S. A., marked by stone and pipe, on south bluff of Illinois river 1 mile south of Marquette coal mine; located 300 feet east of dwelling house owned by Joseph Maheux 125 feet north and 5 feet east of intersection of east and west highway with east fence line of N. W. ¼ of N. E. ¼ sec. 30, T. 33 N., R. 1 W , Granville township; a tower 26 feet high was erected	41 18 24.0	89 15 52.4
Indiana, Illinois & Iowa railroad bridge over Illinois river, center of draw span	41 18 50.9	89 16 48.7
Moronto, 1.5 miles northeast of station, road crossing, center of track	41 18 03.4	89 16 53.3
Moronto, 1,000 feet north of station, 150 feet north of elevator No. 14, road crossing center of main track	41 17 09.9	89 17 39.8
Mark, 0.8 mile north of, T. 15 N., R. 11 E., near center sec. 20, north rail at road crossing	41 16 29.3	89 15 09.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Mark, at east edge of, 30 feet northeast to large stump, 30 feet southwest to corner of burnt store	41 15 52.8	89 15 00.6
T. 18 N., R. 11 E., south corner secs. 31 and 32, T road north, center of ea t and west road, 25 feet north to center of triangle	41 29 43.0	89 15 26.2
T. 17 N., R. 11 E., north cor. secs. 5 and 6, wire fence south, center of east and west road	41 29 43.0	89 15 27.9
Arlington, 1.8 miles northwest of, crossroads, 35 feet southwest to John Manning's mailbox, 6 feet northeast to forked willow tree	41 29 43.0	89 15 49.4
T. 17 and 18 N. R. 10 and 11 E., stone corner of sections 1, 6, 31 and 36, at slight bend of road to northwest, 150 feet west of Bureau creek, corner of Clarion and Westfield and LaMoille and Berlin townships	41 29 43.2	89 16 33.8
T. 17 and 18 N., R. 10 E., quar. cor. between s. 1 and 36, T road west, center of north and south road, 30 feet west to mailbox in center of triangle	41 29 43.1	89 17 09.6
T. 17 and 18 N., R. 10 E., south corner secs. 34 and 35, second class T road north, center of east and west road	41 29 43.6	89 18 54.1
T. 18 N., R. 10 E., south quar. cor. sec. 34, T road north, 15 feet west to intersection of crossroads	41 29 43.6	89 19 29.3
T. 17 N., R. 10 E., north quarter corner secs. 3, T road south, 15 feet east to intersection of crossroads	41 29 43.6	89 19 29.7
T. 17 and 18 N., R. 10 E., quarter corner between secs. 4 and 33, stone in intersection of crossroads, 100 feet southwest to schoolhouse	41 29 44.0	89 20 39.5
T. 17 and 18 N., R. 10 E., cor. secs. 5, 6, 31 and 32, center of crossroads	41 29 43.4	89 22 23.7
T. 17 and 18, R. 10 E., cor. secs. 5, 6, 31 and 32, 50 feet southeast of center of crossroads, in northwest corner sec. 5, in corner of wire fence; iron post stamped "Prim. Trav. Sta. No. 9, 1908, Illinois	41 29 43.0	89 22 23.2
T. 17 and 18 N., R. 9 and 10 E., cor. secs. 1, 6, 31 and 36, T road east, center of west edge of triangle, 10 feet east to center of triangle, corner LaMoille, Ohio, Dover and Berlin townships	41 29 42.0	89 23 36.5
Grover, 0.5 mile northwest of station, road crossing the Illinois Valley & Northern railroad track, center of track	41 29 03.7	89 24 28.5
T. 17 N., R. 9 E., north cor. secs. 2 and 3, T roads, 30 feet north to forked maple 10 feet south to center of triangle	41 29 41.8	89 25 56.1
T. 18 N., R. 9 E., south cor. secs. 34 and 35, T road north, center of east and west road, 12 feet north to center of triangle	41 29 41.8	89 25 55.7
T. 18 N., R. 9 E., south corner secs. 33 and 34, T road north, center of east and west road, 30 feet north to center of triangle	41 29 41.7	89 27 06.0
T. 17 N., R. 9 E., north cor. secs. 3 and 4, T road south, center of east and west road, 20 feet southeast to two mailboxes	41 29 41.7	89 27 06.5
T. 18 N., R. 9 E., south cor. secs. 32 and 33, 0.25 mile east of, T road north, sixteenth corner at Limerick, 20 feet west to intersection of crossroads	41 29 41.8	89 27 57.8
T. 17 N., R. 9 E., north cor. secs. 4 and 5, 0.25 mile east of, T road south, sixteenth corner at Limerick, 20 feet east to intersection of crossroads	41 29 41.8	89 27 58.3
T. 18 N., R. 9 E., south quarter cor. sec. 32, T road north, center of east and west road, 25 feet north to center of triangle	41 29 41.8	89 28 50.1
T. 17 N., R. 9 E., north quarter cor. sec. 5, T road south, center of east and west road, 20 feet south to center of triangle	41 29 41.8	89 28 51.0
T. 17 N., R. 9 E., quarter cor. between secs. 30 and 31, 1,180 feet north of, T road west, center of north and south road	41 25 31.9	89 29 59.5
T. 16 N., R. 9 E., near southeast corner section 18, T road south, about 2 miles southwest of Princeton, bridge over Bureau Creek about 1,500 feet east of, 25 feet southeast to bridge, 45 feet west to old log, 5 feet north to center of east and west road	41 21 57.3	89 29 37.4
T. 16 N., R. 9 E., near south edge of section 30, large oak tree in corner of fence at bend of main road to east and second class road to west	41 20 11.7	89 29 53.7
T. 16 N., R. 9 E., north and south line between sections 29 and 30, center of east and west road at fence north	41 20 11.1	89 29 19.3
T. 16 N., R. 9 E., in southeast corner section 29, T road west at red brick school house, center of north and south road, 25 feet west to center of triangle, 35 feet east to corner of school house yard	41 20 21.2	89 28 17.7
T. 16 N., R. 9 E., near east edge of section 32, T road north, center of east and west road, 20 feet north to center of triangle	41 19 42.0	89 28 17.4
T. 16 N., R. 9 E., north and south line between sections 31 and 32, center of road crossing	41 19 37.9	89 29 19.2
T. 15 N., R. 9 E., corner sections 19, 20, 29, 30, stone in center of road at fences east and west	41 15 47.4	89 29 24.9
T. 15 N., R. 9 E., in southeast quarter section 24, T road southwest, 60 feet south to Walnut 15 feet southwest to center of triangle	41 16 01.5	89 23 52.3
T. 15 N., R. 10 E., northwest quarter section 19, in northeast corner of Carl Hosier's front yard, 75 feet west of Chicago, Rock Island and Pacific R. R. crossing of the Hennepin Ferry road and 35 feet west of junction of Ferry road with roads northwest and southwest, 1.25 miles southwest of Bureau Junction, Illinois River Survey bench mark post stamped elev. "469.75 feet Memphis Datum"	41 16 39.7	89 23 01.5

GEOGRAPHICAL POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Hennepin, 1.5 miles northwest of, center of iron bridge	41	15	57.4	89	22	23.1
Hennepin, Illinois River Survey triangulation station, U. S. A. engineers: Marked by stone and pipe; permanent tertiary station, on high left bank of Illinois river, 166 feet north and 20 feet west of northeast corner of intersection of First and Mulberry streets, in Hennepin. A 10 foot tower was built over point	41	15	24.5	89	20	44.0
Hennepin, at southeast corner of Putnam county court house yard, 50 feet northwest of intersection of High and Fifth streets, iron post stamped "Prim. Trav. Sta. No. 13, 1908, ILLINOIS"	41	15	09.8	89	20	30.4
Hennepin, 2 miles east of, center of crossroads	41	15	24.9	89	18	14.6
Hennepin, 3 miles east of, T road south, center of northeast and southwest road, 10 feet north to fence, 60 feet southeast to elm, 50 feet south to center of triangle	41	15	32.1	89	17	06.8
T 15 N., R. 11 E., quarter corner between sections 29 and 30 (?), 1,100 feet west of, T road south, 1.8 miles west of Granville, center of east and west road, 25 feet south to center of triangle	41	15	26.0	89	15	43.2
T. 15 N., R. 11 E., quarter corner between sections 29 and 30 (?), 1,100 feet west of T road south, 40 feet southeast of 1.8 miles west of Granville, corner of fence; iron post stamped "Prim. Trav. Sta. No. 5, 1908, ILLINOIS"	41	15	25.8	89	15	42.9
Granville, 0.5 mile southwest of T road north	41	15	27.0	89	14	25.5

Magnetic declination of east border of quadrangle is 4° 17′ east.
Magnetic declination of south border of quadrangle is 4° 37′ east.
Magnetic declination of north border of quadrangle is 4° 50′ east.
Magnetic declination of west border of quadrangle is 4° 30′ east.

WYANET QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T 17 N., R. 9 E., north quarter corner section 6, T road south, center east and west road 20 feet south to center of triangle	41	29	41.4	89	30	01.4
T. 17 N., R. 9 E., north quarter corner section 6, T road south, 40 feet southeast of, at corner of wire fence; iron post stamped "Prim. Trav. Sta. No. 10, 1908, ILLINOIS"	41	29	41.3	89	30	01.0
T. 17 N. R. 9 E., quarter corner between sections 6 and 7 center of crossroads	41	28	49.9	89	30	01.7
T. 17 N., R. 9 E., quarter corner between sections 7 and 18, T road north, center of east and west road, 25 feet north to center of triangle 180 feet west to T road south	41	27	57.5	89	30	01.3
T. 17 N., R. 9 E., east and west line between sections 18 and 19, T road west on, center of triangle, 150 feet south to church	41	27	05.1	89	30	09.8
T. 17 N , R 9 E., quarter corner between sections 19 and 30, center of crossroads	41	26	12.8	89	30	00.3
T. 17 N. Rs. 8 and 9 E., corner sections 25, 30, 31 and 36, north and south line between Dover and Bureau townships	41	25	19.9	89	30	38.2
T 17 N., R. 8 E., corner sections 25, 26, 35 and 36, T road south, center of east and west road, 20 feet south to center of triangle	41	25	23.2	89	31	47.6
T. 16 and 17 N., R. 8 E., corner sections 1, 2, 35 and 36, T road north, stone in center of east and west road	41	24	31.	89	31	47.3
T. 16 N., R. 8 E., quarter corner between sections 1 and 12, T road west, center of north and south road, 20 feet west to center of triangle, 30 feet east to line fence	41	23	38.3	89	31	12.3
T. 16 N., R. 8 E , quarter corner between sections 1 and 13, T road north, center of east and west road, 15 feet north to center of triangle, 40 feet south to center of maple	41	22	46.0	89	31	11.8
T. 16 N., R. 8 E., east corner sections 12 and 13, second class road north, bend in main road south	41	22	44.7	89	30	37.1
T. 16 N., R. 9 E., corner sections 7 and 18. T road east, center of north and south road, 20 feet east to center of triangle	41	22	43.5	89	30	37.1

GEOGRAPHICAL POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.	Longitude.
T 16 N., R. 9 E., west corner sections 7 and 18, T road eas . 35 feet southeast of, at corner of fence in northwest corner of section 18; iron post stamped "Prim. Trav. Sta. No. 11, 1908, ILLINOIS"	° ′ ″ 41 22 43.3	° ′ ″ 89 30 36.7
T. 15 and 16 N., R 9 E., east and west line between sections 6 and 31, also east and west line between Princeton and Arispie townships, center of road at crossing	41 19 16.3	89 30 15.2
Illinois and Mississippi Canal, at west end of, center of triangle	41 18 50.3	89 30 39.8
Tiskilwa, 1 mile north of center o bridge over Bureau creek	41 18 24.1	89 30 33.4
Tiskilwa, 0.5 mile north of, road crossing Chicago, Rock Island and Pacific R. R., center between main track	41 17 54.6	89 30 35.2
Tiskilwa, T. 15 N., R. 8 and 9 E., corner sections 7, 12, 13 and 18, stone in center of intersection of Main and Princeton streets	41 17 32.7	89 30 35.4
Tiskilwa, 1.25 miles southeast of, second class fork to southwest, 150 feet south of top of hill, center of main road, 15 feet west to telephone pole, 35 feet southwest to center of triangle	41 16 43.1	89 30 01.1

Magnetic declination of east border of quadrangle is 4° 30′ east.

LACON QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 15 N., R. 9 E., corner sections 29, 30, 31 and 32, center of crossroads	41 14 54.8	89 29 24.9
T. 15 N., R. 9 E., corner sections 29, 30, 31 and 32, center of crossroads, 40 feet southeast of, at corner of hedge fence in northwest corner of section 32; iron post stamped "Prim. Trav. Sta. No. 12, 1908, ILLINOIS"	41 14 54.5	89 29 24.5
T. 15 N., R. 9 E., corner sections 28, 29, 32 and 33, T road south, center of east and west road, 5 feet south to center of triangle	41 14 54.7	89 28 15.0
T. 15 N., R. 9 E., corner sections 27, 28, 33 and 34, farm road north, center of east and west road	41 14 54.5	89 27 05.1
T. 15 N., R. 9 E., corner sections 26, 27, 34 and 35, T road north, center of east and west road, 20 feet north to center of triangle, 20 feet south to end o: north and south wire fence	41 14 54.1	89 25 56.4
T. 15 N., R. 9 E., quarter corner between sections 26 and 35, T road west, center of north and south road, 25 feet west to center of triangle 20 feet east to end of wire fence, 225 feet southeast to school house No. 174	41 14 54.0	89 25 21.6
Hennepin, 1 mile southeast of, center of crossroads	41 14 58.0	89 19 40.8
Hennepin, 2.2 miles southeast of, center of stone arch bridge at T road north and south	41 14 31.1	89 18 11.2

Magnetic declination of north border of quadrangle is 4° 37′ east.

Equality, Marion, Morganfield and Shawneetown Quadrangles—Gallatin and Hardin Counties, Illinois—Crittenden and Union Counties, Kentucky.—The following geographic positions were determined by primary traverse in 1908 by Mr. J. R. Ellis, assistant topographer. The line starts from an adjusted position near Cypress Junction, Illinois, and follows public highways south near borders of quadrangles to Peters Creek, Illinois, thence east crossing the Ohio river at Weston, Kentucky, and connecting with an adjusted position at Sturgis, Kentucky.

Equality Quadrangle, Illinois.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Steel bridge over Saline river, just east of, T road north	37 41 55.4	88 15 41.6
Township line, center of T road east on	37 41 20.7	88 16 11.1
T. 9 S., R. 8 E., ¼ cor. south of section 36	37 41 20.7	88 16 16.4
Center of cross roads	37 40 41.0	88 16 28.4
J. C. Baldwin's residence, just north of, center of T road west	37 39 34.8	88 16 11.6
Gibsonia, center of steel bridge over Eagle Fork	37 38 59.1	88 15 39.8
Gibsonia, 1 mile southeast of, stone at T road west	37 38 16.3	88 15 07.3
T. 10 S., R. 9 and 10 E., cor. secs. 25, 30, 31 and 36, in northeast corner of orchard	37 36 56.4	88 15 37.6
Center of T lane east	37 36 15.9	88 16 16.6
T. 10 and 11 S., R. 8 E., cor. secs. 1, 2, 35 and 36	37 36 02.3	88 16 51.5
T. 11 S., R. 8 E., ¼ cor. between secs. 1 and 2, stone	37 35 37.3	88 16 52.0
Philadelphia church and school house, about .2 mile north of, center of T road west at house on hill	37 34 43.2	88 17 05.9
Sparks Hill post office, T road south; 40 feet southeast to corner of store porch, 35 feet east to telephone pole	37 34 29.7	88 15 55.1
T. 11 S., R. 8 E., cor. secs. 12 and 13 (east corner), stone	37 34 16.2	88 15 45.3
Old log house, center of T road west at corner of fence	37 33 07.3	88 15 02.4

Magnetic Declination of east border 4° 12′ east.

Shawneetown Quadrangle, Illinois.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Cypress Junction station, track opposite semaphore	37 43 33.8	88 14 10.7
Center of T road south; 10 feet south to stone ¼ corner between secs. 29 and 30, T. 9 S., R. 9 E	37 42 40.0	88 14 48.4
T. 9 S., R. 9 E., cor. secs. 29, 30, 31 and 32	37 42 13.6	88 14 49.2
C. B. Swogirt's residence, .3 mile northwest of, at cross roads; 40 feet north and 30 feet east to center of cross roads; iron post stamped "Prim. Trav. Sta. No. 33, 1908, Illinois"	37 37 44.8	88 14 26.3
T. 11 S., R. 9 E., corner at turn of road (no numbers)	37 32 58.1	88 14 40.2
Rock Creek store and post office, .5 mile west of, center of T road east	37 32 36.8	88 14 23.5
Rock Creek store and post office, about .5 mile south of, forks just east of school house	37 32 18.9	88 13 50.0
Baptist Church and school house, .8 mile south of, center of T lane east	37 31 37.0	88 13 50.4
Baptist Church and school house, 1.5 miles south of, forks of road at south end of lane; 20 feet north to corner of fence	37 31 01.0	88 13 51.6

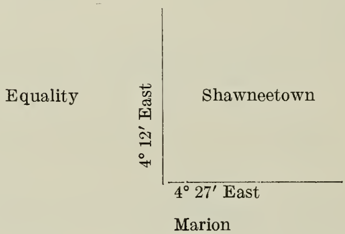
Magnetic Declination west border 4° 12′ east.

MARION QUADRANGLE, ILLINOIS.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Peters Creek store, 200 feet east of turn of road at, on north side of road; iron post stamped' Prim. Trav. Sta. No. 34, 1908, Illinois	37 29 37.8	88 14 05.6
T. 12 S., R. 9 E., cor. secs. 5, 6, 7, and 8	37 29 50.8	88 13 35.1
Richard Frailey's mail box, center of road at	37 29 43.7	88 12 44.9
T. 12 S., R. 9 E., cor secs. 3, 4, 9 and 10	37 29 50.1	88 11 21.1
Love school house No. 1, just east of, T road west; 35 feet north and 10 feet west to corner telephone post	37 29 50.0	88 10 08.1
Cave in Rock, in north part of, center of T road east; 30 feet west to advertising board	37 28 30.6	88 09 53.7
T. 12, S., R. 8 and 9 E., cor secs. 7, 12, 13 and 18	37 28 56.2	88 09 07.8
T. 12 S., R. 8 E., cor. secs. 7, 8, 17 and 18	37 28 56.9	88 07 59.9
Cave in Rock, 2 miles east of, south side of Cave in Rock and Fords Ferry, at T road northeast; 10 feet northeast to center of T road; iron post stamped "Prim. Trav. Sta. No. 35, 1908, Illinois	37 28 50.3	88 07 47.9
T road south to Fords Ferry, at barn; 20 feet southwest to corner fence post	37 28 46.0	88 06 30.6
Three mail boxes, forks of road at	37 29 02.0	88 05 56.6
Old Ferry Landing opposite Weston, Ky., cut on southwest face of honey locust tree with two nails driven in center; large cross	37 29 04.7	88 04 39.3

Magnetic Declination north border 4° 27′ east.



Albion, Carmi, Enfield, New Harmony and New Haven Quadrangles—Edwards, Wayne and White Counties.—The following geographic positions were determined by primary traverse in 1908 by Mr. J. R. Ellis, assistant topographer. The line starts from an adjusted position at Grayville and follows west along public highways to Burnt Prairie, thence south near borders of quadrangles to southwest corner of Carmi quadrangle and east to adjusted position two miles south of Maunie. The second line starts from an adjusted position at Maunie and follows public highways north to the original position at Grayville:

Carmi Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Bridge, 600 feet east of center of T road north	38	00	01.4	88	14	06.9
Little Wabash river, west bank of, at old ferry landing	38	00	28.8	88	11	47.2
Storms post office, center of T road south at	38	00	26.0	88	10	46.0
Storms post office, 1 mile east of, center of T road north	38	00	27.0	88	09	39.4
T road north, on line between secs. 13 and 14, T. 6 S., R. 11 E	38	00	11.2	88	03	36.4
T. 6 S., R. 10 & 11 E., ¼ cor. between secs. 13 and 18, center of bridge	38	00	10.6	88	02	30.2
Maunie, 2 miles south of, center of T road north	38	00	02.6	88	02	30.3

Magnetic Declination south border 3° 44′ east.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Maunie, 1.5 miles north of, center of cross roads	38	03	26.5	88	02	44.7
T. 5 S., R. 10 and (11 fraction) E., cor. secs. 19, 24, 25 and 30, cross roads	38	04	05.5	88	02	27.8
T. 5 S., R. 10 and (11 fraction) E., cor. secs. 13, 18, 19 and 24, stone	38	04	57.4	88	02	27.2
Maunie, 3 miles north of, west side of T road east; iron post stamped "Prim. Trav. Sta. No. 28, 1908, Illinois"	38	04	58.6	88	02	27.5
Wooden bridge, T road northeast, just north of, 22 feet east to tree	38	04	57.0	88	01	12.5
T road east to ford on Wabash river, 15 feet east to honey locust tree	38	05	40.3	88	01	00.2
T. 5 S., R. 14. W., cor. secs. 5. 6, 7 and 8, stone	38	06	54.2	88	00	45.3
Phillipstown, about 2 miles south of, in southwest part of Dick Pond school house yard; iron post stamped "Prim. Trav. Sta. No. 29, 1908, Illinois," elevation 378 feet	38	07	07.7	88	00	44.8
T. 4 and 5 S., R. 14 W., cor. secs. 5, 6, 31 and 32, T road south	38	07	46.0	88	00	44.6
Phillipstown, center of T road east at store at	38	08	35.6	88	01	15.8
Phillipstown, 1 mile north of, 35 feet west and 45 feet south to center of cross roads, at northeast corner of cross roads; iron post stamped "Prim. Trav. Sta. No. 30, 1908, Illinois"	38	09	30.4	88	01	21.8
T. 4 S., R. 14 W., cor secs. 17, 18, 19 and 20, sandstone	38	10	22.1	88	00	42.8
Calvin station, 1 mile south and .3 mile west of, 15 feet north and 15 feet east to center of T road, at south side of T road north; iron post stamped "Prim. Trav. Sta. No. 31, 1908, Illinois"	38	11	40.2	88	01	20.0
Calvin station, 140 feet northeast of, north and south road crossing Big Four railroad at	38	12	36.5	88	01	02.6
Joseph Bumps farm, road crossing Big Four railroad at	38	13	52.4	88	00	09.0

Magnetic Declination east border 3° 41′ east.

Albion Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Grayville, in southeast corner of Williamson hotel grounds; iron post stamped "Prim Trav. Sta. No. 21, 1908, Illinois	38	15	35.1	87	59	29.1
Grayville, across the street from Illinois station on east side of Illinois Central railroad; iron post stamped "Prim Trav. Sta. No. 32, 1908, Illinois"	38	15	30.7	87	59	26.5
Grayville station, Big Four railroad	38	15	36.9	87	59	29.4
T. 3 S., R. 14 W., cor secs. 18 and 19 (west corner), center of T road east.	38	15	24.9	88	01	36.6
T. 3 S., R. 11 E. (fraction,)cor. secs. 18 and 19 (east corner), center of T road west	38	15	23.5	88	01	36.6
Grayville, 3.5 miles west of, center of T road south	38	15	23.9	88	03	26.8
T. 3 S., R. 10 E., cor. secs. 14, 15, 22 and 23, center of cross roads, White-Edwards county line	38	15	24.2	88	04	32.5
T. 3 S., R. 10 E., cor secs. 15, 16, 21 and 22, center of T road north, White-Edwards county line	38	15	24.3	88	05	38.9
T. 3 S., R. 10 E., cor secs. 9, 10, 15 and 16, stone, center of crss roads.,	38	16	16.3	88	05	38.4
T. 3 S., R. 10 E., cor secs. 8, 9, 16 and 17	38	16	16.5	88	06	44.5
T. 3 S., R. 10 E., cor secs. 7, 8, 17 and 18, center of T road north	38	16	16.8	88	07	49.1
Wayne-Edwards county line, 1 mile north of White county line, at northeast corner of T road east; 10 feet southwest and 20 feet south to corner secs. 7, 12, 13 and 18, T. 3 S., R. 9 and 10 E. to Wayne-Edwards county line; iron post stamped "Prim. Trav. Sta. No. 22, 1908, Illinois"	38	16	17.7	88	08	58.2
T. 3 S., R. 9 E., cor secs. 11, 12, 13 and 14.	38	16	15.9	88	10	05.1
T. 3 S., R. 9 E., cor secs. 10, 11, 14 and 15, center of cross roads	38	16	19.3	88	11	10.6
T. 3 S., R. 9 E., cor secs. 9, 10, 15 and 16	38	16	19.1	88	12	16.2
Gum store, center of cross roads at	38	16	19.7	88	12	48.8
T. 3 S., R. 9 E., cor secs. 8, 9, 16 and 17, stone	38	16	20.2	88	13	21.9
T. 3 S., R. 9 E., ¼ cor. between secs. 17 and 18, 20 feet east to center of T road west	38	15	54.9	88	14	29.3
Burnt Prairie, .3 mile north of, on White-Wayne county line at turn of road; iron post stamped "Prim Trav. Sta. No. 23, 1908, Illinois".	38	15	28.8	88	15	24.4

Magnetic Declination south border 3° 35′ east.

Enfield Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Burnt Prairie, 1 mile south of, center of T road east	38	14	11.0	88	15	15.3
Burnt Prairie, 2 miles south of, center of cross roads	38	13	31.7	88	15	05.0
T. 3 S., R. E., cor secs. 31 and 36 (south corner), T road north	38	12	51.7	88	15	37.7
T. 4 S., R. 9 E., cor secs. 1 and 6 (north corner)	38	12	51.7	88	15	38.2
Frasher's store, .8 mile north of, center of T road east	38	12	37.6	88	17	01.4
Frasher's store, center of T road east	38	11	45.3	88	17	02.2
Cross roads school house, center of T road west	38	10	40.6	88	17	03.7
Skillet Creek Bridge, U. S. Department of Agriculture Drainage, 360 feet southwest of, at turn of road; iron post stamped "384" (?) Elev. 383.6	38	09	50.6	88	17	04.6
Balls store, .5 mile north of, T road west	38	09	02.0	88	16	49.1
T. 4 S., R. 8 E., cor .secs. 25, 26, 35 and 36, stone at turn of road	38	08	30.4	88	16	50.2
Balls store, 1 mile south of, at turn of road at township line; 6 feet north and 4 feet east to cor. secs. 35 and 36 (south corner,)T. 4 S., R. 8 E.; iron post stamped "Prim. Trav. Sta. No. 24, 1908, Illinois"	38	07	37.8	88	16	51.2
T. 5 S., R. 8 E., cor secs. 1 and 2 (north corner), T road south	38	07	37.8	88	16	50.2
T. 5 S., R. 8 E., cor secs. 1, 2, 11 and 12, center of T road east	38	06	45.0	88	16	50.8
T. 5 S., R. 8 E., cor secs. 11, 12, 13 and 14	38	05	53.1	88	16	51.6
Mile post 198, north and south road crossing L. & N. R. R	38	05	23.2	88	16	51.7
T. 5 S., R. 8 E., cor secs. 13, 14, 23 and 24 center of T road east at school house No. 6	38	05	01.6	88	16	51.6
T. 5 S., R. 8 E., cor secs. 23, 24, 25, 26, center of cross roads	38	04	09.5	88	16	52.6
T. 5 S., R. 8 E., cor secs. 25, 26, 35 and 36, center of cross roads	38	03	17.7	88	16	53.6

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 5 S., R. 8 E., cor secs. 35 and 36 (south corner), 10 feet east to cross roads	38	02	25.3	88	16	54.8
T. 6 S., R. 8 E., cor secs. 1 and 2 (north corner)	38	02	25.3	88	16	54.5
T. 6 S., R. 8 E., cor. secs. 1, 2, 11 and 12, stone	38	01	33.2	88	16	54.6
T. 6 S., R. 8 E., cor secs. 23, 24, 25 and 26, stone, center of cross roads at Ditney school house	37	59	48.1	88	16	54.3
Ditney church, southwest corner of yard; 30 feet west and 30 feet south to ¼ corner between secs. 19 and 24, T. 6 S., R. 8 E., cross roads; iron post stamped "Trim. Trav. Sta. No. 25, 1908, Illinois	37	59	22.0	88	16	53.9
Anna B. Polle's mail box, T road east; 21 feet southwest to mail box	37	59	22.4	88	15	48.4

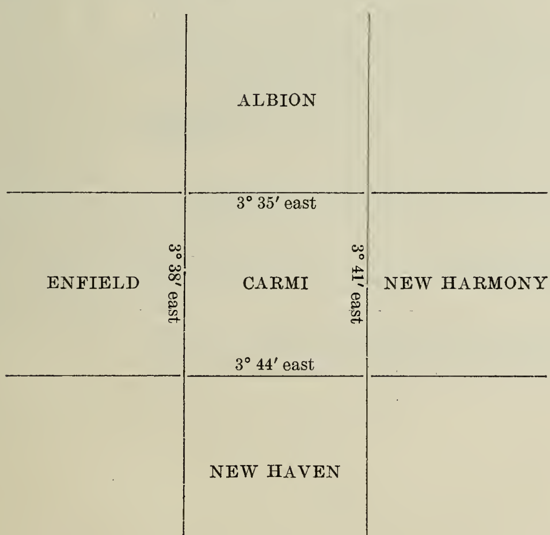
Magnetic Declination of east border 3° 38′ east.

NEW HAVEN QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Anna B. Polle's mail box, 1.3 miles east of, center of T road west	37	59	21.6	88	14	23.8
T. 6 S., R. 9 E., cor secs. 15, 16, 21 and 22	37	59	47.6	88	12	26.9
Storms post office, 2 miles east and .8 mile south of, at southeast corner of T road north; 10 feet west and 15 feet north to center of T road; iron post stamped "Prim. Trav. Sta. No. 26, 1908, Illinois"	37	59	46.2	88	08	33.8
T. 6 S., R. 10 E., cor secs. 17, 18, 19 and 20, stone	37	59	46.0	88	08	01.0
T. 6 S., R. 10 E., cor secs. 16, 17, 20 and 21	37	59	45.6	88	06	54.8
T. 6 S. R. 10 E., cor secs. 15, 16, 21 and 22; stone	37	59	45.5	88	05	49.0
T. 6 S., R. 10 E., cor secs. 14, 15, 22 and 23, center of cross roads	37	59	45.2	88	04	42.9
Rising Sun Village, .33 miles southeast of, under center of st el telephone tower on west side of Wabash river; iron post stamped "Prim. Trav. Sta. No. 27, 1908, Illinois"	37	59	49.0	88	01	21.9

Magnetic Declination of north border 3° 44′ east.



Bridgeport, Mt. Carmel, Olney and Vincennes Quadrangles—Edwards, Lawrence, Richland and Wabash Counties.—The following geographic positions on U. S. Standard datum were determined by primary traverse in 1908 by J. R. Ellis, assistant topographer. The line starts from Claremont triangulation station of the U. S. Lake Survey and Coast and Geodetic Survey and follows south along public highways to Parkersburg triangulation station, thence to southwest corner of Bridgeport quadrangle, thence east to point near Patton and north along border of quadrangle to primary traverse station No. 11, 1907, Illinois:

Bridgeport Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
St. James church, center of cross roads at	38	44	49.2	87	59	54.4
T. 1 N., R. 14 W., ¼ corner between secs. 20 and 21, center of cross roads	38	30	15.3	87	59	05.2
Mills Prairie school house No. 13, at northeast corner of T road north, 0.25 mile east of, 25 feet south and 25 feet west to ¼ corner between secs. 21 and 22, T. 1 N., R. 14 W., elevation 435; iron post stamped "Prim. Trav. Sta. No. 13, 1908, Illinois"	38	30	15.2	87	57	57.8
Edwards-Wabash county line, center of bridge over Bonpas creek	38	30	18.4	87	56	53.2
T. 1 N., R. 14 W., ¼ corner between secs. 23 and 24, center of T road south	38	30	14.6	87	55	48.1
T. 1 N., R. 13 and 14 west, ¼ corner between secs, 19 and 24, center of T road west	38	30	14.5	87	54	41.2
Barney Prairie church, stone at T road west at	38	30	10.0	87	47	55.0
Harmony school house, insouthwest corner of yard at; 35 feet south and 30 feet west to ¼ corner between secs. 20 and 21, T. 2 N., R. 12 W., cross roads; elevation 445; iron post stamped "Prim. Trav. Sta. No. 17, 1908, Illinois"	38	35	26.0	87	45	34.1
T. 2 N., R. 12 W., ¼ corner between secs. 20 and 21, center of cross roads	38	35	25.7	87	45	34.5
T. 2 N., R. 12 W., corner secs. 16, 17, 20 and 21	38	35	52.0	87	45	34.0
T. 2 N., R. 12 W., corner secs. 8, 9, 16 and 17	38	36	44.6	87	45	33.4
Grant school house, in southeast corner of yard at; elevation 446; iron post stamped "Prim. Trav. Sta. No. 18, 1908, Illinois"	38	37	38.2	87	45	33.4
T. 2 N., R. 12 W., corner secs. 4, 5, 8 and 9, center of cross roads	38	37	37.5	87	45	33.1
T. 2 N., R. 12 W., corner secs. 4 and 5 (north corner), T road south	38	38	34.6	87	45	33.0
T. 3 N., R. 12 W., corner secs. 32 and 33 (south corner), T road north	38	38	34.6	87	45	34.6
Bridgeport, at northeast corner of cross roads about 3 miles south of; iron post stamped "Prim. Trav. Sta. No. 19, 1908, Illinois"	38	39	28.0	87	45	33.8
T. 3 N., R. 12 W., corner secs. 28, 29, 32 and 33, cross roads	38	39	27.7	87	45	34.0
Bridgeport, at northwest corner of cross roads 2 miles south of, elevation 489; iron post stamped "Prim. Trav. Sta. No. 20, 1908, Illinois"	38	40	20.7	87	45	34.3
T. 3 N., R. 12 W., corner secs. 20, 21, 28 and 29, center of cross roads	38	40	20.4	87	45	33.9
T. 3 N., R. 12 W., corner secs. 16, 17, 20 and 21, center of T road west	38	41	13.2	87	45	33.5
T. 3 N., R. 12 W., corner secs. 8, 9, 16 and 17	38	42	06.2	87	45	33.3
Bridgeport, Main street crossing Baltimore & Ohio railroad	38	42	19.2	87	45	35.3
T. 3 N., R. 12 W., corner secs. 4, 5, 8 and 9, center of cross roads	38	42	59.3	87	45	33.1
T. 3. N., R. 12 W., corner secs. 4 and 5 (north corner,) 20 feet north to T road south	38	43	52.6	87	45	33.0
Westport, 5.75 miles due south of; on east side of T road west at Fairview church, in top of concrete block 8 by 8 by 20 inches; aluminum tablet stamped "Prim. Trav. Sta. No. 11, 1907, Illinois"	38	44	46.0	87	45	35.3

Magnetic Declination of east border of quadrangle 3° 50′ east.
Magnetic Declination of south border of quadrangle 3° 47′ east.
Magnetic Declination of west border of quadrangle 3° 36. east.

OLNEY QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 3 N., R. 14 W., corner secs. 5 and 6 (north corner), center of T road south	38	43	56.4	88	00	10.4
T. 3 N., R. 14 W., corner secs. 5, 6, 7 and 8, center of cross roads at school house	38	43	04.8	88	00	10.7
T. 3 N., R. 14 W., corner secs 7, 8, 17 and 18, center of cross roads	38	42	10.2	88	00	11.0
T. 3 N., R. 14 W., corner secs. 17, 18, 19 and 20, center of cross roads	38	41	16.5	88	00	11.3
T. 3 N., R. 14 W., corner secs. 19, 20, 29 and 30, center of cross roads	38	40	23.9	88	00	11.6
T. 3 N., R. 14 W., stone corner secs. 29, 30, 31 and 32	38	39	30.9	88	00	12.0
T. 2 and 3 N., R. 14 W., corner secs. 5, 6, 31 and 32, center of cross roads	38	38	37.9	88	00	12.2
Whittaker school house and Methodist church, at northeast corner of cross roads; 20 feet south and 20 feet west to center of cross roads; iron post stamped "Prim. Trav. Sta. No. 11, 1908, Illinois"	38	37	45.6	88	00	12.6
T. 2 N., R. 14 W., stone corner secs. 5, 6, 7 and 8, center of cross roads.	38	37	45.4	87	00	12.8
T. 2 N., R. 14 W., corner secs. 7, 8, 17 and 18, cross roads	38	36	52.5	88	00	13.1
T. 2 N., R. 14 W., corner secs. 17, 18, 19 and 20, cross roads at Oak Grove school house	38	35	59.8	88	00	13.3
T. 2 N., R. 14 W., ¼ corner between secs. 29 and 30, center of cross roads	38	34	39.9	88	00	13.6
T. 2 N., R. 14 W., stone ¼ corner west side of sec. 30, at T road east at Harrison school house	38	34	40.4	88	01	26.0
Parkersburg triangulation station, in fractional section 30, T. 2 N., fractional range 11 E.; stone post	38	34	51.5	88	01	49.0
T. 2 N., R. 14 W., corner secs. 30 and 31 (west corner), T road east, Richland-Edwards county line	38	34	13.9	88	01	26.1
Fractional R. 11 E., corner secs. 30 and 31 (east corner)	38	34	13.6	88	01	26.1
T. 1 and 2, N., R. 14 W., stone corner secs. 6 and 31 (west corner), cross roads	38	33	20.6	88	01	26.2
Range Line road crossing Illinois Central railraod	38	32	41.2	88	01	26.1
T. 1 N., R. 14 W., and fractional R. 11 E., cor. secs. 7, 7, 18 and 18, cross roads	38	31	34.7	88	01	26.4
T. 1 N., R. 14 W., and fractional R. 11 E., cor. secs. 18, 18, 19 and 19.	38	30	41.6	88	01	26.4
West Salem, at west side of T road east, at Schwartzlow's school house, 1 mile south of; 20 feet east and 10 feet south to center of T road; iron post stamped "Prim. Trav. Sta. No. 12, 1908, Illinois"	38	30	15.3	88	00	29.3

Magnetic declination of east border of quadrangle 3° 36′ east.

MT. CARMEL QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 1 N., R. 13 W., cor secs. 19, 20, 29 and 30, center of cross roads	38	29	48.1	87	53	31.1
Friendsville, at southeast corner of cross roads 3 miles west and 5 miles south of; iron post stamped "Prim Trav. Sta. No. 14, 1908, Illinois".	38	29	47.3	87	52	24.1
T. 1 N., R. 13 W., cor secs. 20, 21, 28 and 29, cross roads	38	29	47.4	87	52	24.4
T. 1 N., R. 13 W., cor secs. 21, 22, 27, and 28, center of cross roads	38	29	46.9	87	51	16.8
T. 1 N., 13 W., stone cor. secs. 22, 23, 26 and 27	38	29	46.0	87	50	09.9
T. 1 N., R. 13 W., cor secs. 23, 24, 25 and 26, T road west	38	29	45.2	87	49	01.2
T. 1 N., R. 12 W., cor secs. 19, 20, 29 and 30, center of T road east	38	29	43.2	87	46	45.3
Patton, on east side of T road west, 1 mile north and .5 mile west of; elevation 416; iron post stamped "Prim. Trav. Sta. No. 15, 1908, Illinois"	38	29	42.8	87	45	36.5
T. 1 N., R. 12 W., cor secs. 20, 21, 28 and 29, center of T road west	38	29	42.8	87	45	36.8

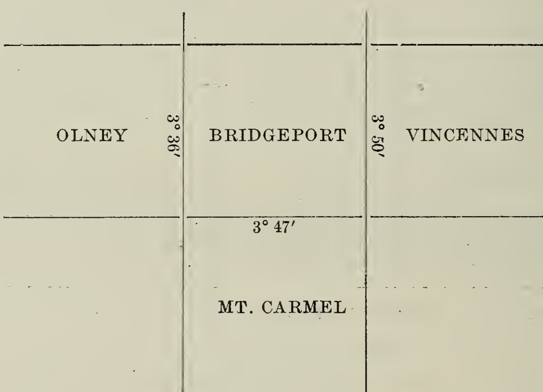
Magnetic declination of north border of quadrangle 3° 47′ east.

VINCENNES QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Patton, at southeast corner of T road west, 1.25 miles north and .5 miles east of; 15 feet north and 20 feet west to center of T road; iron post stamped "Prim. Trav. Sta. No. 16, 1908, Illinois"	38 29 54.5	87 44 29.8
T. 1 N., R. 12 W., cor secs 15, 16, 21 and 22	38 30 34.3	87 44 30.7
T. 1 N., R. 12 W., cor secs. 9, 10, 15 and 16, center of cross roads	38 31 27.3	87 44 31.8
T. 1 N., R. 12 W., cor secs. 3, 4, 9 and 10, center of T road west at school house	38 32 20.0	87 44 32.6
T. 1 N., R. 12 W., stone corner secs. 3 and 4 (north corner)	38 33 14.9	87 44 33.4
T. 2 N., R. 12 W., stone cor secs. 33 and 34 (south corner)	38 33 14.9	87 44 29.3
T. 2 N., R. 12 W., cor secs. 27, 28, 33 and 34, Lawrence-Wabash county line	38 34 06.8	87 44 28.5
Harmony school house, 1 mile east of, center of cross roads	38 35 25.4	87 44 27.0

Magnetic declination west border of quadrangle 3° 50′ east.



Baldwin, Chester, Renault and Sparta Quadrangles—St. Clair, Randolph and Monroe Counties.—The following geographic positions were determined by primary traverse in 1908 by J. R. Ellis, assistant topographer. The line starts from primary traverse station mark No. 18, 1907, and follows public highways near the east border of quadrangles to point two miles south of Blair, thence west to point near Missouri Junction and north via Marigold, Ruma and Red Bud to primary traverse station mark No. 21, 1907:

BALDWIN QUADRANGLE.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Louis Krang's mail box, center of T road east at	38 00 43.1	89 45 52.3
Methodist church, T road north, 0.2 miles west of, 20 feet north to center of bridge	38 00 30.5	89 46 59.8
T. 6 S., R. 6 W., ¼ corner between secs. 17 and 18, T road south	38 00 30.9	89 47 33.2
T. 6 S., R. 7 W., cor secs. 13 and 24 (east corner)	38 00 03.1	89 48 57.8
Ellis Grove, near center of triangle formed by three large trees and forks of road at Joseph Labririe's farm, about 2 miles east of; iron post stamped "Prim. Trav. Sta. No. 3, 1908, Illinois"	38 00 19.2	89 52 50.0
Old Bluff Ferry, at corner of Jeff Derouse's garden at forks of road, about ¾ mile west of; iron post stamped "Prim. Trav. Sta. No. 4, 1908, Illinois"	38 01 11.6	89 58 32.5
St. Louis road at fork of road up bluff	38 01 41.3	89 59 19.6

Magnetic declination south border of quadrangle 4° 51′ east.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ruma, at southwest corner of T road east 1½ miles south of, 20 feet east and 20 feet north to center of T road east, elevation 522; iron post stamped "Prim. Trav. Sta. No. 6, 1908, Illinois	38 07 00.6	89 59 55.4
T. 5 S., R. 8 W., cor secs. 4 and 5 (north corner), center of T street south	38 08 06.4	89 59 54.4
Ruma, at southeast corner of cross station, 25 feet north and 30 feet west to cor. secs. 32 and 33 (south corner) T. 4 S., R. 8 W., elevation 442; iron post stamped "Prim. Trav. Sta. No. 7, 1908, Illinois"	38 08 06.2	89 59 51.9
Red Bud, at southeast corner of cross roads, 1.5 miles south of, 30 feet north and 30 feet west to center of cross roads, elevation 460; iron post stamped "Prim. Trav. Sta. No. 9, 1908, Illinois"	38 11 36.3	89 59 37.5
T. 4 S., R. 8 W., cor secs. 8, 9, 16 and 17	38 11 36.7	89 59 54.4
Red Bud, main street crossing Mobile and Ohio R. R. just east of station	38 12 57.8	89 59 38.4
Red Bud, at west side of main street and just north of M. & O. R. R., elevation 444; iron post stamped "Prim. Trav. Sta. No. 10, 1907, Illinois"	38 12 58 8	89 59 38.8
Randolph, St. Clair county line, gate post supporting iron gate	38 13 20.6	89 59 33.3
T. 3 S., R. 8 W., stone cor secs. 28, 29, 32 and 33	38 14 12.8	89 59 54.6
Primary Traverse Station No. 21, 1907, Illinois	38 14 39.0	89 59 54.8

Magnetic declination east border of quadrangle 4° 57′ east.
Magnetic declination west border of quadrangle 5° 02′ east.

CHESTER QUADRANGLE.

GEOGRAPHIC POSTITIONS ALONG HIGHWAYS NEAR NORTH BORDER OF QUADRANGLE.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
New Palestine, center of T road west, 0.5 mile southwest of	37 59 37.0	89 49 14.2
New Palestine, center of T road east, 0.3 mile south and 0.8 mile west of, 7 feet northwest to stone corner	37 59 38.2	89 50 19.9
Guide board "Ellis Grove 1½ miles—Preston 8", T road west, 20 feet east to Whiteoak	37 59 32.0	89 53 23.6
T. 6 S., R. 7 W., ½ cor. between secs. 20 and 29	37 59 13.4	89 53 57.4
Reilly Lake school house, road opposite	37 58 43.6	89 54 53.4
Reilly Lake station, road crossing Illinois Southern R. R., 0.5 mile northwest of	37 59 09.2	89 55 39.0
Reilly Lake station, 21 feet northwest of blazed tree, about 200 feet south of Iron Mt. R. R., 0.35 mile west of; spike in top of elm post	37 58 59.4	89 55 35.8
St. Louis road at T road east (center of) Reilly Lake Ferry, Okaw river	37 59 07.4	89 57 19.8
St. Louis road crossing under Iron Mt. railroad	37 59 51.1	89 57 36.8

Magnetic declination of north border of quadrangle 4° 51′ east.

Renault Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Glascow Farm, T road northeast, 23 feet due south to well	38	02	31.4	90	00	57.4
John A. Mudd's residence, center of T road southwest	38	02	59.0	90	00	17.2
T. 5 S., R. 8 W., ¼ cor between secs. 20 and 29	38	04	34.3	90	00	29.6
Marigold, in southeast part of school house yard at, elevation 565; iron post stamped "Prim. Trav. Sta. No. 5, 1908, Illinois"	38	04	47.9	90	00	23.3
Marigold, center of T road west, 1 mile north of	38	05	41.7	90	00	28.5
Camp creek, center of bridge over	38	06	21.8	90	00	11.8
Ruma, at T road west, 1.75 miles north of, 20 feet south,and 20 feet east to center of T road west, elevation 419; iron post stamped "Prim. Trav. Sta. No. 8, 1908, Illinois"	38	09	25.8	90	00	07.3

Magnetic declination of east border of quadrangle 5° 02′ east.

Sparta Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR WEST BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Center of crossing of north and south and northwest and southeast roads	38	14	12.1	89	43	16.9
White Oak station, road crossing Illinois Central railroad	38	13	41.1	89	43	33.3
T. 3 and 4 S., R. 6 W., cor secs. 1 ,2, 35 and 36, St. Clair-Randolph county line	38	13	10.1	89	43	18.7
Sc otland school house, center of cross roads, 0.25 mile north of	38	12	17.1	89	43	01.4
T. 4 ꝏ., R. 6 W., cor. secs. 11, 12, 13 and 14	38	11	24.8	89	43	18.6
T. 4 S., R. 6 W., ¼ cor. between secs. 11 and 14, T road south	38	11	25.0	89	43	52.4
T. 4 S., R. 6 W., ¼ cor. between secs. 14 and 23 (stone corner), cross roads	38	10	32.9	89	43	52.1
T. 4 S., R. 6 W., ¼ cor. between secs. 23 and 26, T. road east, 15 feet south to bridge	38	08	40.8	89	43	52.6
Sparta, at east side of T road west, 1 mile north of, 20 feet west to center of sec. 36, T. 4 S., R. 6 W., iron post stamped "Prim. Trav. Sta. No. 1, 1908, Illinois"	38	08	20.6	89	42	44.7
T. 4 and 5 S., R. 6 W., ¼ cor between secs. 1 and 36, T road east	38	07	56.0	89	42	44.9
Sparta station, north and south road crossing Mobile & Ohio R. R. about 400 feet west of	38	07	14.2	89	42	45.0
T. 5 S., R. 6 W., cor secs. 11, 12, 13 and 14	38	06	12.5	89	43	18.9
Cor. secs. 13, 14, 23 and 24, center of cross roads, about 0.3 mile west of.	38	05	20.2	89	43	45.7
Blair, center of cross roads, 2 miles north of	38	04	27.3	89	44	17.6
T. 6 S., R. 6 W., cor secs. 26, 27, 34 and 35	38	03	34.1	89	44	28.5
T. 5 and 6 S., R. 6 W., cor secs. 2, 3, 34 and 35, center of cross roads at Blair	38	02	41.4	89	44	29.3
Blair, at northeast corner of cross roads, 2 miles south of, 25 feet west and 15 feet south to center of cross roads; iron post stamped "Prim. Trav. Sta. No. 2, 1907, Illinois"	38	00	59.1	89	44	28.1

Magnetic declination of west border of quadrangle 4° 57′ east.

STUDIES OF ILLINOIS COAL.

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INTRODUCTION.[1]

(BY H. FOSTER BAIN.)

The recently aroused public interest in the conservation of our natural resources has peculiar importance to mining men, since they deal with resources which are stored products. Within certain limits, the fertility of a worn-out soil may be restored, deforested areas can be replanted, one year's wasted water supply is followed by another; but coal and ores, once taken out, cannot be mined again, and should therefore be conserved with especial care. This means, however, not that mining should be restricted, but that it should be done most economically and with the minimum of waste.

As a first step, we should take stock of our reserves and study our methods of production. This is peculiarly true of coal, because of the intimate relations of fuel supply and industrial supremacy, the speed with which our coal-fields are being exploited, and the large waste attending the mining and ultilization of coal. In 1906, according to the U. S. Geological Survey, the value of the total mineral production of the United States was $1,902,517,565, of which $513,079,809 was derived from the coal mines. In 1907, notwithstanding the unfavorable industrial conditions of the second half of that year, the coal output of the country was 480,450,042 tons, valued at $614,831,549. It is impossible to determine exactly the waste of coal attending this production; but it is perhaps approximately accurate to say that, for each ton mined and marketed, another ton was lost in the processes of handling and preparation, or abandoned underground. Engineers know that the waste in burning the coal was even greater. In short, only a very small proportion of the energy residing in our coal-beds is utilized under present conditions.

Any effort to remedy these conditions must be based upon careful studies and much experimental work. The U. S. Geological Survey has taken the lead, so far as relates to the national coal-researves; but no single organization can hope to do all the work, and the individual states must be prepared to take part in it. In Illinois a beginning has already been made. Through the State Engineering Experiment Station and the State Geological Survey, various problems relating to the occurrence, production, and utilization of Illinois coals are being studied. In the papers which follow, some of the results of these investigations are

[1] Most of the following papers were read at the Chattanooga meeting of the American Institute of Mining Engineers, October, 1908.

given, supplemented by discussions of certain phases of the subject by Messrs. Rice and Bement, engineers especially familiar, through private practice, with the particular questions involved.

Illinois has a large interest in everything relating to coal. Though far behind Pennsylvania in present production, it ranks second among the states, with an output in 1907 of 51,317,146 tons, valued at $54,-687,382. In the amount of its coal-reserves it undoubtedly outranks any eastern or central state, and its geographic position adds importance to the fact.

Illinois Coal as a Type.

The character and composition of Illinois coals has been discussed in some detail by Prof. S. W. Parr,[1] who has especially pointed out the inert character of a large amount of the volatile matter present. Table I is an average analysis based on 24 analyses, or averages of analyses, of face-samples, made by the State Geological Survey. The individual analyses have been weighted in proportion to the production of the various counties, and the figures are all based on the coal as received, including mine-moisture and occluded gas. Detailed analyses are given on later pages.

Table I.—*Average Analyses of Illinois Coal.*

Moisture. Per Cent.	Volatile. Per Cent.	Fixed Carbon. Per Cent.	Ash. Per Cent.	Sulphur. Per Cent.	Calorific Capacity. B. t. u.
12.60	35.99	41. 2	10.51	3.22	11,046

Table II gives the composition of commercial deliveries in Chicago from a number of representative Illinois mines compared with face-samples. The figures of lump, mine-run and screenings represent in each case the average of a large tonnage, as actually delivered and sampled by the Fuel Engineering Co. For comparison, analyses of face-samples from the same mines are included in the table.

Table II.—*Average Composition of Illinois Coals. (Commercial Deliveries.)*

Samples.	Sulphur. Per cent.	Moisture. Per cent.	Dry ash. Per cent.	Cal. cap. (dry) B. t. u.	Number of mines.
Face	3.35	12.27	10.88	12,779	22
Lump	3.08	10.40	10.7	12,827	14
Mine run	3.10	11.60	15.50	11,990	14
Screenings	3.90	13.80	19.10	11,319	19

[1] Bulletin No. 3, Illinois State Geological Survey, pp. 27 to 79 (1906).

In making comparisons it should be noted that both the ash and the B.t.u. values are calculated on a "dry-coal" basis. In later pages face-samples from various parts of the State are considered.

Briefly, all Illinois coals are bituminous, and, as contrasted with their principal market-competitors, are relatively high in sulphur, ash, moisture, and volatile matter. Moreover, as Professor Parr has pointed out, 40 per cent. of the volatile matter, or 14 per cent. of the whole coal, is non-combustible, as contrasted with 22 and 4.2 per cent. respectively, in the case of Pocahontas, Va., coal, and 47 and 21.63 per cent. in North Dakota lignite. Illinois coals are essentially free-burning and non-coking. They are mainly used for heating and power-generation, and have no large or direct use in metallurgy. The amount of suphur present precludes their use for furnace-coke and complicates the problem of storage. The large proportion of volatile introduces a smoke-problem when the coals are burned in cities, and the high content in ash also detracts from their value. Despite all these facts, they have a high average value for miscellaneous heating and for steam-generation, and many of them are excellently adapted for use in gas-producers. In a general way, it may be said that the Illinois-Indiana coals are not inherently as valuable as the coals of the Appalachian basin, but more valuable than those of the Michigan and Western Interior fields, excepting limited areas in western Arkansas and eastern Oklahoma.

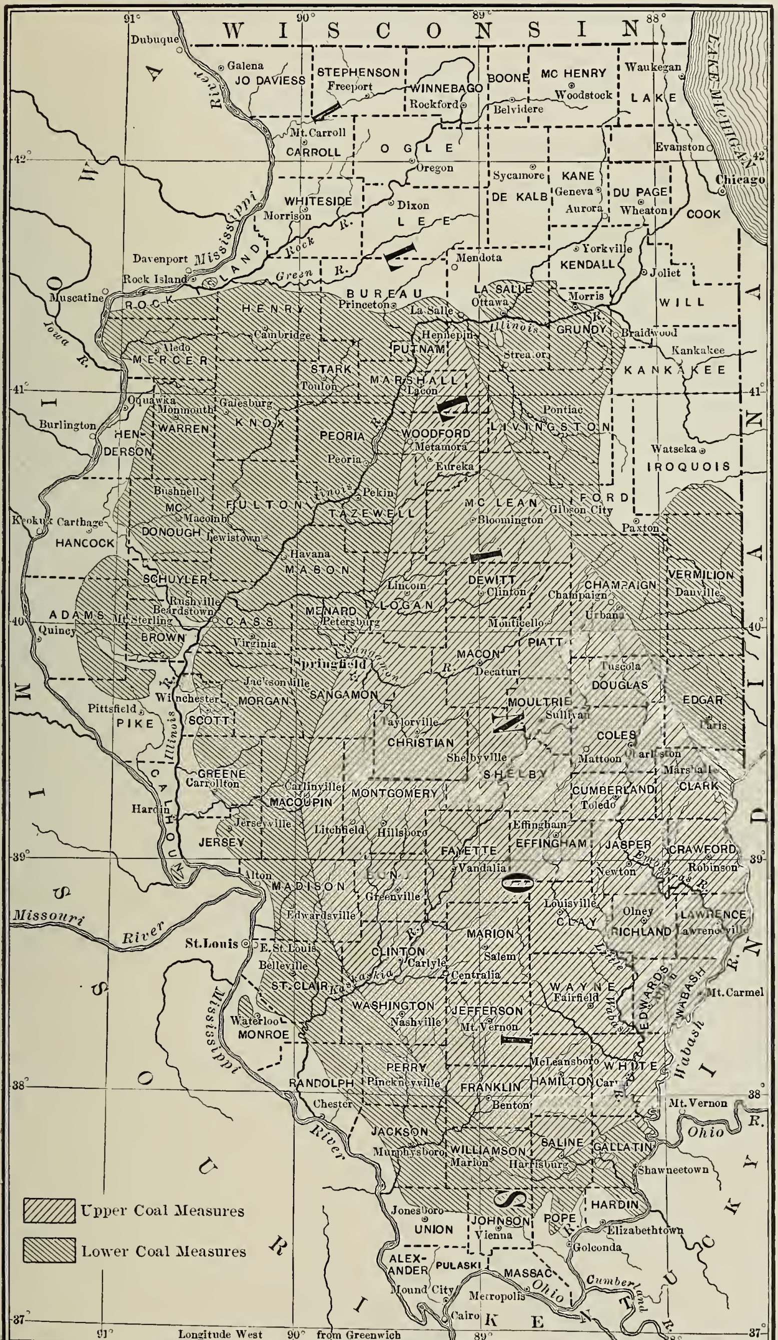
Statement of the Problem.

To estimate the position of Illinois coals in the markets of the future, the following topics must be considered: (1) the distribution and amount of coal available in the field: (2) the quality of the coal; (3) mining conditions and costs; (4) present methods of utilization; (5) possible future methods of utilization; and (6) the relations of the deposits to markets.

A complete discussion of all these factors is at present impracticable. In the present series of papers the first has been briefly considered by F. W. DeWolf, Assistant State Geologist. Certain phases of the second are discussed by Messrs. Lindgren and Barker on the basis of work done under direction of Professor Parr for the State Survey and the Experiment Station. The third is discussed by G. S. Rice, Consulting Engineer. The fourth is discussed in two papers, the first of which, treating of the domestic consumption of coal, has been prepared by J. M. Snodgrass as a result of work being done under the direction of L. P. Breckenridge of the Engineering Experiment Station. The problem of burning Illinois coals without smoke, a most important one in such a consideration as the present, is taken up by A. Bement, Consulting Engineer. The possible future methods of utilization of our coals have some light shed on them through the discussion of the weathering of coal by W. F. Wheeler and the artificial modification of coal at low temperatures by C. K. Francis. Both papers are based upon work done under

Professor Parr in the laboratories of the University of Illinois. Finally, I have pointed out in a general way the relations of the coal-field to the market.

While there are many obvious gaps in this symposium, it is hoped that the papers forming it will give information, important not only to producers and users of Illinois coals, but to many others as well.



Map Showing Upper and Lower Coal Measures.

THE COAL RESOURCES OF ILLINOIS.

(BY FRANK W. DEWOLF.[1])

GEOGRAPHIC RELATIONS.

Coal-bearing rocks underlie three-fourths of Illinois, including 85 of its 102 counties. The coal area may be estimated at from 36,000 to 42,000 square miles—the largest area of bituminous coal within any single state. The unproductive part, as shown in Pl. 2, includes the northern one-fifth, a narrow belt bordering the Mississippi river, and a half-dozen small counties at the southern extremity.

PRODUCTION AND RESERVES.

The production in 1907, according to the U. S. Geological Survey, was 51,317,146 tons, with a spot value of $54,687,382—the largest production so far reached, representing a gain of 23.7 per cent over that of 1906. Illinois thus ranks second among producing states, a position which it has held for twenty-three years, except in 1906, when West Virginia, on account of labor conditions, ranked second. There are more than 400 shipping mines scattered through fifty-two counties, and thirty-three other counties are probably underlain by coal, but as yet not commercially developed.

Considering the production of the State for the past thirty years, in five-year totals, shown in Table I, minor fluctuations are lessened and the rapid strides of increase are made prominent.

TABLE I.—*Production from 1878 to 1907 in 5-year Totals.*
(Round Numbers.)

YEARS.	Tons. Production.	INCREASE.	
		Tons.	Per cent.
1878–1882	32,651,000		
1883–1887	59,764,000	27,113,000	83.0
1888–1892	75,247,000	15,483,000	25.9
1893–1897	78,377,000	3,130,000	4.1
1898–1902	131,077,000	52,700,000	67.3
1903–1907	204,646,000	73,569,000	56.1

[1] Assistant State Geologist.

While the total production has steadily increased, the percentage rate of increase has, on the whole, diminished, and this has been interpreted by Parker, Fleming, and others to mean that, under present commercial tendencies, there will come, many years hence, for every producing state, a time when the rate of increase will be zero, and after which the total production will slowly diminish. Doubtless many factors will arise to modify the operation of this tendency, and in the case of Illinois the exhaustion of the coal-resources lies far in the future.

Estimates have recently been made of the total amount of coal originally under the State, and the amount still remaining. Such calculations are extremely uncertain; but, assuming the exploitation of all coal-beds twenty-four inches or more in thickness, and estimating according to present knowledge the thickness of each seam, the conclusions given in Table II may be regarded as reasonable and prudent, though subject to revision.

TABLE II.—*Estimate of Illinois Coal-Resources.*
(Round Numbers.)

		Tons.
Original coal		136,966,000,000
Mined to close of 1907	645,868,309	
Wasted to close of 1907 (at 62 per cent recovery)	245,429,957	
Mined and wasted to close of 1907		891,000,000
Total reserves		136,075,000,000

The largest area within which the amount of coal present is uncertain occupies the east central counties, where drill-records are scattered. A recent estimate by M. R. Campbell of the U. S. Geological Survey includes beds twenty inches and more in thickness, and places the original supply at 240,000,000,000 tons.

GEOLOGIC RELATIONS.

The Illinois coal-region comprises about three-fourths of the Eastern Interior field, the remainder lying in neighboring parts of Indiana and Kentucky. It may once have been continuous with the Appalachian, Northern Interior, and Western Interior fields. There is great resemblance to the stratigraphy of the Indiana-Kentucky areas; and structurally the Eastern Interior basin is a unit. The geology of the coal-fields is now being studied in detail by the State and U. S. Geological Surveys in coöperation. The data here given were obtained in the course of this study.

STRUCTURE.

Generalized cross-sections of the Illinois field, compiled by several geologists, show it to be spoon-shaped, the beds dipping gently towards

a long axis which lies a short distance west of LaSalle and continues a little east of south to the southwest county of Indiana. The deepest part of the basin is in the vicinity of White county, and from here the strata rise more rapidly to the south than to the north, averaging over a considerable distance forty feet, and locally 100 feet per mile. The sides of the "spoon" show some minor longitudinal folds, notably the anticline which runs from LaSalle through the Illinois oil-field towards Princeton, Ind., a steep monocline at Duquoin, and a gentle anticline at Belleville. The southern margin of the basin shows numerous minor faults and at least one of consequence, which runs west and a little south from Shawneetown, and has a down-throw to the north of over 1,000 feet. This separates the greater part of the basin from a narrow southern belt of rugged country, characterized by massive sandstones, but containing local areas of thick coal. Igneous dikes and other features along the southern margin of the basin indicate that the structure of the coal-field is in part related to the orogenic movements of southern Illinois and western Kentucky.

This structure has localized active mining around the edges of the basin, where the coal is most easily reached. Since, in the lowest area, the thick coal-beds lie 1,200 feet or more below the surface, they will probably not be utilized there for some time.

STRATIGRAPHY.

General Stratigraphy.—The rocks of the Coal Measures or Pennsylvanian series consist of alternating beds or lenses of shale and sandstone, with which are mingled thinner strata of limestone, coal, and fire-clay There appear to be three general divisions of the rocks:

(1) A basal portion, composed chiefly of massive sandstones, and, according to David White, corresponding in age to the Pottsville formation of the Appalachian trough. This has a thickness of 650 feet or more in Johnson and Hardin counties, but diminishes rapidly to the west and north, being nearly or quite absent over much of the State. Coal No. 1 of the western counties lies near the top of this formation. Lower coals occur in southeastern Illinois and western Kentucky, and some of these were formerly mined.

(2) The second division extends from Coal No. 2 of the western and northern counties to Coal No. 7, and thus includes all the seams mined for shipment in the State. It is dominated by shale and contains a subordinate amount of sandstone. In age, it corresponds closely to the Allegheny formation or Lower Productive Measures of Pennsylvania, since, on the basis of plant-fossils, Coal No. 7 lies at or near the Upper Freeport, and No. 2 near the Kittanning horizon. This formation extends over nearly the whole coal-area, but its lower beds are not well known in the central part of the basin. At Peoria the total thickness is about 200 feet, and at Mattoon it appears to be 300 feet.

(3) The third and topmost division is dominated by shales, and contains no coals of present importance, though some are locally mixed on a small scale. It occupies much of the coal-area, and reaches its greatest

thickness (1,200 feet or more) in the vicinity of Hamilton and White counties. From 275 to 350 feet above its base occurs the Carlinville limestone, which, in the earlier State geological work, was accepted as a dividing line between the Upper and Lower Coal Measures.

The total thickness of the Pennsylvania rocks probably exceeds 2,000 feet, but around the edges of the basin much has been removed by erosion, and in a large part of the State the basal division is thin or absent. David White, who has contributed largely to recent studies of it, has shown that the earliest beds were deposited in a restricted area in the southeastern counties, and that the favorable conditions for deposition of the Coal Measures gradually spread over the State, overlapping the eroded surface of the rocks, which are progressively older to the north.

The Coals.—In the work of early State surveys the Illinois coals were numbered from 1, at the bottom, to 16, at the top, and the same method was used in Kentucky, where, however, additional beds of the lower coals were found. The numbers, therefore, are confusing; Illinois Nos. 5 and 7 being identical respectively with Kentucky Nos. 9 and 11. Even in Illinois the numbers have been incorrectly assigned, and the same bed is now known under several numbers. Thus, Coal No. 7 of Saline and Williamson counties is undoubtedly the seam known as No. 6 and 7 at Duquoin, and as No. 6 in the Belleville region, and is probably the same as No. 6 at Peoria and No. 5 south of Chatham. The tracing of the Illinois coals is one of the interesting studies now in progress. Satisfactory work seems possible on the horizon of Coal No. 2, which White has found present from the northern long-wall district through the western belt of counties to Murphysboro; and also on the so-called "Blue Band" seam, called in different localities, as already remarked, Nos. 5, 6, and 7. Other beds of reasonable persistence will probably be found; but most of the Pennsylvania rocks seem to constitute "interfingering" lenses of comparatively local extent. There are at least four coal-seams of wide distribution, and from 3 to 9 feet thick, besides others of local importance.

MINING CENTERS AND DISTRICTS.

The State may perhaps be divided into natural districts on the basis of the varying fuel-value of the coals; and this study is now under way. The following notes, however, relate to important geographical districts or mining centers recognized by the trade. The use of numbers does not imply correct correlation of the beds.

Williamson, Franklin and Perry Counties.—Williamson county led the production of the State in 1907 with more than 5,500,000 tons, and its coal has a rapidly growing market. No. 7, the Blue Band seam, which is from 5 to 10 feet thick, averaging nine feet over a large area, is the greatest producer. The top-coal, about twenty inches thick, is frequently left to support the shale roof, and locally is withdrawn after the rooms have been mined out. The "blue band" is a clay or shale parting from one to two inches thick, and about twenty inches above the

floor. There is a general northeast dip, amounting to sixty feet per mile in the central part of the county. Local faults occur, sometimes with from twenty to thirty feet displacement. The seam outcrops near Marion, but elsewhere is reached by shafts, usually from 100 to 200 feet deep. There is no sharp line between this field and its neighbors. The same seam is known in Perry and Franklin counties and in counties to the east. It maintains an approximate uniformity in physical character and thickness, but varies from place to place in fuel-value. At Duquoin on the west it is nearly horizontal, but on the east it dips rapidly and becomes thicker and somewhat better in quality. At Spillertown, another seam, four feet thick, is mined sixty feet below No. 7. This seam is probably equivalent to No. 5 of Saline county, and if we may judge from borings, may have a wide distribution in the Williamson county district.

Sangamon, Macoupin, Christian, Logan and Macon Counties.—The Springfield district, extending into several adjoining counties, has long been one of the most important. Sangamon county produced more than 5,000,000 tons in 1907. The coal of the district is commonly known as No. 5, though recent work by Mr. Savage and the writer tends to confirm the suggestion made by Messrs. Bement,[1] Rice,[2] *et al.*, that there are probably two distinct beds mined in the district, No. 5 in the area north of Chatham and No. 6 south of that town. No. 5 is cut by numerous vertical clay veins from a few inches to four feet in thickness, and lacks the "blue band" which characteristically occurs near the floor of No. 6. Both beds may have a limestone cap-rock within a few feet of the coal. These coals are thought to be of the same age as Nos. 5 and 6 of the Peoria region, and the upper bed, No. 6, is probably the same as No. 6 of Belleville and No. 7 of Williamson county. No. 5 lies about 250 feet below the surface in the vicinity of Springfield, at 425 feet at Mount Olive on the south, and at 600 feet at Decatur on the east. The average thickness is a little less than six feet at Springfield, about 4.5 feet at Decatur, and from six to eight feet in Macoupin county. There are three higher coals, all too thin to be mined at present, and lying respectively, 50, 100 and 175 feet above No. 5. There are likewise several coals below No. 5, but drilling has not been adequate to determine their commercial values. At Riverton to the east a diamond-drill record reports two seams, each measuring about thirty-two inches, lying 125 and 250 feet, respectively, below No. 5. There are also several other coals, which locally may develop into thick seams. A 4-foot bed is reported to occur in this vicinity at a depth of 320 feet below No. 5, but is known only from a churn-drill record.

St. Clair, Madison, Clinton and Randolph Counties.—St. Clair county produced more than 4,500,000 tons in 1907. This district, known as the Belleville district, is not sharply set off from its neighbors, since the same coal-bed is mined under similar conditions in adjoining counties.

[1] State Geological Survey, Bulletin No. 3, p. 19.
[2] This Bulletin, p. 1127.

It is again the "Blue Band" seam, with its parting near the base, and its limestone caprock, usually above the slate, but in some places directly overlying the coal itself. The thickness is from five to seven feet over much of this area, and the seam is reached by shafts from 100 to 300 feet deep. It outcrops west of Belleville, and is eroded from the western part of the county. The general dip of the beds in St. Clair county, as demonstrated by the recent work of Dr. J. A. Udden, is eastward, from ten to twenty feet per mile. Local variations are frequent, and faults of six feet displacement have been observed; but the general conditions are uniform. As to quality, analyses of face-samples indicate considerable irregular variation, so that no average can be given for the entire district. Borings indicate the presence of two deeper seams, one about fifty and the second from 100 to 150 feet below No. 6; but their general workability has not been demonstrated.

Vermilion County.—During 1907 Vermilion county produced nearly 3,000,000 tons. It has long been an important area, shipping principally to the Chicago market. As described by M. R. Campbell,[1] there are three persistent coal-seams, two of which are worked. The top or Danville bed (No. 7) appears west of Vermilion river, and is mined along the outcrop and by shafts from 75 to 200 feet deep. It is about six feet thick around Danville, but more nearly three feet ten miles further south. A band of bone or clay, lying from 6 to 20 inches above the floor, occurs in some of the reported sections. The Grape Creek coal (No. 6) lies from 20 to 80 feet below the Danville, and is more important. It becomes thicker southward from Danville, and covers many square miles with a thickness of from 6 to 9 feet. A band of shale or sulphur frequently occurs about two feet above the floor. Several borings have shown a seam from 185 to 220 feet below the Grape Creek, and from 4 to 8 feet thick, but badly broken by bands of shale and limestone.

Saline County.—Saline county is one of the newest and most rapidly growing producers. In 1907 its output was about 2,125,000 tons, a gain of 125 per cent upon 1906. There are two seams, Nos. 7 and 5, underlying the northern two-thirds of this county and much of Gallatin on the east, each approximately five feet thick, and lying from 90 to 150 feet apart vertically. The upper is the Blue Band coal, which runs west into Williamson county and north into White and Hamilton. The lower seam is free from regular bands and has considerably higher heating-value, though in this respect the upper seam also is excellent. The seams outcrop to the south, and have a general northward dip of from 25 to 75 feet per mile. Thus, the coal which outcrops at Equality, in Gallatin county, is from 900 to 1,000 feet deep in Hamilton county, twenty-five miles north. Farther northeast, diamond-drill records in the oil-fields indicate the presence of the same coals. An E.-W. fault, with a downthrow to the north of more than 1,000 feet, crosses the middle of Saline and Gallatin counties, and is, perhaps, related to some minor faults and igneous intrustions in this district.

[1] Danville Folio, U S. Geological Survey.

Fulton and Peoria Counties.—Fulton county produced more than 2,000,000 tons in 1907, and Peoria about half as much. No recent work has been done by the Survey in Fulton, but Peoria has been studied carefully by Dr. J. A. Udden. Here the principal seam, called No. 5, is from 4 to 4.5 feet thick, free from persistent partings, and dips gently SE., usually about five feet, and only locally as much as sixty feet per mile. Shafts reach the coal at from 75 to 150 feet. In all, seven beds are present here within 300 feet of the surface, but only four have proved thick and persistent enough to be mined. No. 1, or the Lower Pottstown, is about 250 feet below No. 5, and about four feet thick, but is divided by a shale-parting, three feet thick, about fifteen inches below the roof. This coal is no longer worked. No. 2 is about 130 feet below No. 5 and thirty inches thick. It is worked by the long-wall method, and, according to the analysis of a mine-sample, appears to be a little better in quality than No. 5, though mining conditions may render the commercial output inferior. No. 6 lies 70 feet above No. 5, and has the characteristic band and roof-materials of the Blue Band seam, variously named Nos. 5, 6 and 7. The coal is a little less than four feet thick, but lies near the surface, and has been locally faulted and broken, so as to render mining difficult.

LaSalle, Bureau and Grundy Counties.—The LaSalle district includes three principal counties which produce together more than 5,000,000 tons. The largest production is obtained by long-wall mining from seam No. 2, or the "Third Vein." The coal averages about three feet in thickness, and is blocky and of good quality. The method of mining introduces considerable ash in the screenings, and washers are used. The seam is reached by shafts from 125 to 450 feet deep. About 140 feet above No. 2 lies the seam, four feet thick (or more), called No. 5 in former reports. About forty feet above it lies No. 7, which is extensively worked under the uplands of the region by room-and-pillar methods. The geological work of the present season should assist in the correlation of these upper beds with others of the State, and bring up to date our knowledge of this important field.

Western Field.—The counties along the western edge of the State are underlain by coals No. 1 and No. 2, recently traced by David White from LaSalle and Rock Island counties on the north to Murphysboro on the south. At present, mining in these counties is largely from No. 2, for local use. The lower seams usually measure from 2 to 3 feet only, but the highlands contain areas of thicker upper coals also. In view of the present and future development of the clay industries of this district, the coal promises to be of great importance. The clay lies between No. 1 and No. 2, at the horizon of the famous Chelthenham clay of St. Louis, Mo.

THE SAMPLING AND ANALYSIS OF ILLINOIS COALS.

(By J. M. Lindgren.[1])

Introduction.

The importance of accurate sampling is evident. No matter how careful the analysis, the results are of little value if the sample be not truly representative. For example, if a sample of 100 pounds of coal, selected for quartering, contains a piece of pyrite larger than the pieces of coal, and weighing three pounds, the inclusion of this pyrite in the sample would increase the ash by about three pounds, and correspondingly raise the percentage of ash shown by subsequent analyses. Such a piece of pyrite should have been discarded as abnormal; yet, had it been of average size and presumably present in every other 100-pound sample similarly taken, it would have been normal, and should not have been discarded. Another mistake is made in sampling when the best-looking piece of coal is selected as representative of the pile. Such samples are too frequently taken. Still another improper method is to select portions from different parts of the top of the pile, disregarding the coal underneath. This leads, in many cases, to serious errors, because the coal underneath is very likely to be of different character from that on the top.

Methods of Sampling.

SAMPLING STOCK PILES.

Probably the most common method of sampling coal is to select definite portions from different parts of the pile. In the case of a carload of coal, sampled as it is unloaded, a good method is to select every twenty-fifth or thirtieth shovelful from different portions of the car. In sampling coal as it comes from the mine, it is customary to select a portion from each lot dumped into the coal-chutes.

W. F. Wheeler and Prof. S. W. Parr have invented a sampler which has given satisfactory results on coal of small size, and in the use of which it is unnecessary to handle the entire pile. It is made in two parts, one of which consists of a heavy, galvanized iron pipe, six feet long and eight inches in diameter, having at one end handles for revolving it, and at the other end, on opposite sides, two notches, slightly sharpened, so that, when the pipe is revolved, they will cut into the coal. The

[1] Assistant Chemist, Engineering Experiment Station.

second part is an iron rod, slightly longer than the pipe and sharpened at one end, to which end is securely fastened a pipe of thin galvanized iron 7 feet by 5 inches in size, which will just fit into part No. 1. Inside this pipe is a series of sectional shutters, at right angles to the rod, which are arranged so as to fold fan-fashioned when operated in one direction, but to unfold and close the opening when operated in the opposite direction through the turning of a lever-arm at the top of the iron rod. Part No. 2 also has handles for revolving. The apparatus is used as follows: Part No. 1 is showed slightly into the coal, whereupon part No. 2 is inserted, and, by revolving, pushed further into the coal. When the interior pipe is filled, the bottom is closed by means of the lever, and the pipe is pulled out and emptied of its load of coal. Part No. 1 is then pushed still farther into the coal and a second portion is taken out; and so on, until the bottom of the pile is reached. By means of part No. 2 the coal is removed just in front of part No. 1, so that it can easily be advanced. Such a device, of course, can only operate on small sizes of coal.

Table I gives ash-determinations, calculated to a dry-coal basis, of coal sampled in the three ways just described.

TABLE I.—*Dry Ash of Coal Sampled by Three Methods.*

Kind of Coal.	From coal-chutes. Per cent.	From cars. Per cent.	From bins. By pipe sampler. Per cent.
Sangamon egg	17.87	16.63	17.45
Sangamon screenings	17.13	17.04	17.22
Herrin egg	14.32	14.90	14.32
Herrin screenings	14.13	14.37	15.66
Westville egg[1]	10.55	13.98	14.21
Westville screenings[1]	17.88	13.69	14.69

FACE-SAMPLING.

In taking a sample of coal which is to represent the quality of coal in the mine, it is extremely difficult to get a face of coal which is truly representative. Such a sample rarely represents the quality of coal actually mined, principally because of carelessness in mining. The results obtained at the St. Louis Exposition Fuel-Testing Plant showed that the usual method of mine-sampling cannot be relied on to represent the average commercial product of the mine.[2] In many cases, however, it will correspond fairly with the lump coal.

[1] In this case only the car-sample and the sample taken by pipe sampler are comparable, because the sample from the chutes was picked clean at the top after each dump, before a shovelful was selected for a sample, leaving a portion about 2 ft. thick, which was not cleaned. Of course, when the car was sampled during unloading this error was avoided.

[2] Professional Paper No. 48, United States Geological Survey, p. 142 (1906).

TABLE II.—*Distribution of Ash in Coal During Quartering Two-Pound Sample with Riffle After Crushing to One-Eighth Inch Maximum Diameter.*

(Ash equals percentage of dry coal.)

(Whole sample)	2 lb.			
(½ sample)	1 lb. 11.37 per cent. ash*	1 lb.		
(¼ sample)	8 oz. 11.47 per cent. ash*	8 oz. 11.26 per cent. ash*	8 oz. 11.32 per cent. ash	8 oz.
(⅛ sample)	4 oz. 11.49 per cent. ash*	4 oz. 11.45 per cent. ash*	4 oz. 11.25 per cent. ash	4 oz. 11.26 per cent. ash
(1/16 sample)	2 oz. 11.31 per cent. ash*	2 oz. 11.66 per cent. ash*	2 oz. 11.43 per cent. ash	2 oz. 11.47 per cent. ash
(1/32 sample)	1 oz. 11.32 per cent. ash*	1 oz. 11.30 per cent. ash*	1 oz. 11.26 per cent. ash	1 oz. 12.06 per cent. ash
(1/64 sample)	½ oz. 11.07 per cent. ash*	½ oz. 11.56 per cent. ash*	½ oz. 11.43 per cent. ash	½ oz. 11.16 per cent. ash
(1/128 sample)	¼ oz. 11.43 per cent. ash	¼ oz. 10.70 per cent. ash	¼ oz. 11.91 per cent. ash	¼ oz. 11.20 per cent. ash

* Calculated from two halves of sample

A face-sample is taken in the following manner by the State Geological Survey: A face of coal, which represents as nearly as possible the average coal in the mine, is cleaned by taking off a layer of 2 or 3 inches, after which all loose pieces are picked off the face and roof. A large piece of oil-cloth is then spread out on the floor to catch the coal as it is sampled. A strip of coal at least five pounds to the foot is cut down with the pick. Any bone, blue-band, or other impurity exceeding three-eighths inches in thickness is discarded.

Quartering.

A sample of coal having been selected by any of the above methods, is next reduced to an amount suitable for a working-sample in the laboratory. If it is in lumps, these are broken up to about egg-size, pieces of pyrite, clay, etc., being removed and crushed, and then returned to the pile and the whole thoroughly mixed. After quartering, opposite quarters are kept; the remaining coal is crushed to about nut-size and again thoroughly mixed and quartered, and the opposite quarters, occupying the position of the ones which were not taken first, are selected. This method is continued until a sample of from 600 to 800 g., and of pea-size, is obtained. The sample is then ready for analysis.

In order to determine to what extent a sample of coal could be quartered and still retain its original constitution with regard to ash, W. F. Wheeler conducted the following experiment: A two pound sample of coal, obtained in the ordinary manner, was selected and quartered in the usual way, using a riffle for obtaining the working-sample for each division.

Fractional portions, representing ¼, 1-8, 1-16, 1-32, 1-64, and 1-128 of this sample, were separately analyzed for ash. The results, exhibited in Table II, showed a marked accordance, the sample representing 1-32 being the only exception.

Methods of Keeping Samples.

Face-samples are shipped to the laboratory from the mine in cylindrical tin cans, conforming to the U. S. Geological Survey standard, Each has a screw top about which rubber tape is wound to make it air-tight. S. W. Parr and W. F. Wheeler[1] have shown that coals deteriorate rapidly after mining and exposure to air. The nature of these losses is discussed on later pages by Messrs. Barker and Wheeler. Because of this deterioration it is desirable that samples be analyzed as quickly as possible after mining, and that they be kept air-tight. Coal-samples are usually kept in the Lightning or Mason jars. Parr and Wheeler have shown that the Mason jar does not make as perfect a seal as the Lightning.

In Bulletin No. 17 of the Engineering Experiment Station of the University of Illinois, S. W. Parr and N. D. Hamilton showed that coals submerged in water deteriorate but little, and, while this method of keeping samples is not customary, it seems to be a very good one.

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[1] Journal of the American Chemical Society vol. xxx., No. 6, p. 1027 (June, 1908).

Methods of Analysis.

AIR-DRYING LOSS.

The sample should weigh approximately 700 g. The air-drying loss is determined by the loss in weight which the sample suffers upon drying at room-temperature for from 24 to 48 hours. It may be explained that air-drying loss is determined merely to bring the sample into equilibrium with the surrounding air as regards moisture, so that it can be weighed without subsequent loss or gain of moisture seriously affecting accuracy.

OVEN-DRYING LOSS.

After having determined the air-drying loss, the sample is ground to buckwheat-size, quartered to about 150 g., pulverized so as to pass a 60-mesh sieve, and placed in a half pint Lightning jar. It is next thoroughly shaken, and 1 g. is weighed into a weighing-bottle of about 10 cc. capacity, the glass stopper of which fits closely over the top of the bottle. This bottle, with lid off, containing the coal, is heated at 105° to 108°C. for one hour ,either in a toluene or an electric oven, after which the stopper is replaced and the bottle transferred to a desiccator, and allowed to cool, after which it is weighed. The loss in weight is called oven-drying loss.

ASH.

Either the residue from the determination of oven-drying loss or a fresh sample is used for this determination. In either event it is placed in a weighed porcelain crucible and heated slowly for half an hour over a low Bunsen flame. By this method all the volatile matter is driven off and the coal does not coke. Next, the flame is raised and the coal stirred with a platinum wire to hasten the combustion of the remaining carbon. When this is accomplished, the crucible is put in the blast for half an hour, with occasional stirring to insure complete combustion, after which it is weighed and the unburned residue reported as ash.

Table III.—*Analyses of Coal No. 5, in Saline County.* (7 Samples.)

	As Received.			Oven-Dry.		
	High.	Low.	Aver.	High.	Low.	Aver.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	6.64	4.43	5.90	....	....	....
Vol. matter	36.20	33.48	34.69	38.52	35.66	36.88
Fixed carbon	52.82	47.87	50.41	55.25	50.94	53.66
Ash	10.89	7.17	8.98	11.58	7.62	9.55
Sulphur	3.30	2.19	2.60	3.52	2.30	2.77
B. t. u.	12,883	12,159	12,552	13,700	12,942	13,197

TABLE IV.—*Analyses of Coal No. 6 from St. Clair, Madison and Clinton Counties. (21 Samples.)*

	As Received.			Oven-Dry.		
	High.	Low.	Aver.	High.	Low.	Aver.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	15.91	9.41	12.30	....	....	....
Vol. matter[1]	40.80	29.95	35.92	45.05	34.72	40.94
Fixed carbon[1]	45.50	37.43	40.68	52.75	42.91	46.46
Ash	14.26	9.33	10.84	16.56	9.69	11.72
Sulphur	4.59	1.39	3.55	5.29	1.65	4.04
B. t. u.	11,523	9.916	10,965	12,982	11,639	12,500

Analyses of best and poorest samples, based on B. t. u. as received.

	As Received.		Oven-Dry.	
	Best.	Poorest.	Best.	Poorest.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	9.44	14.81	....	....
Vol. matter	40.80	30.87	45.05	36.24
Fixed carbon	39.59	40.21	43.72	47.20
Ash	10.17	14.11	11.23	16.56
Sulphur	3.96	2.55	4.37	2.99
B. t. u.	11,523	9.916	12,723	11,639

VOLATILE MATTER.

1 g. of coal is weighed into a tared platinum crucible, with evenly-fitting cover, placed on a platinum triangle and heated 7 min. by means of a Bunsen burner, having a flame of 20 cm. high. The distance from the bottom of the crucible to the top of the burner should be about 7 cm. After weighing, the volatile material is calculated by subtracting the moisture from the loss in weight due to heating.

FIXED CARBON.

The fixed carbon is determined by calculation and is the result obtained by substracting the moisture, ash, and volatile matter from 100.

CALORIFIC VALUE.

Determinations of the heating-power in terms of B. t. u. are made with a Mahler calorimeter under carefully standardized conditions.

[1] Determined only for 18 samples.

Analyses of Illinois Coals.

The State Geological Survey has determined the composition and heating-value of the Illinois coals in the seam for many localities by face-sampling and analysis, according to the uniform methods above described. The laboratory-work has been done by W. F. Wheeler and J. M. Lindgren under the direction of Prof. S. W. Parr. Most of the samples have come from scattered localities, and are only approximately representative of the seam for particular districts because of variations which occur, locally, from mine to mine. The available results of this general study are presented in Table V. More detailed studies have been made in connection with quadrangle surveys in the Saline county and Belleville regions. These show great uniformity in the first field, which involves Coal No. 5 (Table III), and considerable variation in the latter field, which covers parts of St. Clair, Madison and Clinton counties, and from which the Blue Band or so-called No. 6 coal is produced. (Table IV).

TABLE V.—*Analyses and Heat-Values of Illinois Coals.*

County.	Local No. of seam.	Mine sample. As received. Moisture.	Volatile matter	Fixed carbon.	Ash.	Sulphur.	B. t. u.	Oven-dry. Volatile matter.	Fixed carbon.	Ash.	Sulpnur.	B. t. u.	Laboratory number.
		Per ct	Per ct	Per ct	Per ct	Per ct	Per ct	Per ct	Per ct	Per ct	Per ct		
Christian	5	11.82	......	......	11.90	4.15	10,760	......	......	13.50	4.71	12,203	742
Fulton	5	15.09	35.39	38.09	10.63	3.21	10,573	41.68	45.80	12.52	3.79	12,450	1,404
Franklin	7	10.62	......	......	7.87	0.67	11,751	......	......	8.82	0.76	13,148	419,420
Franklin	7	14.40	......	......	6.90	1.02	11,459	......	......	8.08	1.19	13,400	461
Gallatin	5	4.47	36.10	49.07	10.36	3.56	12,645	37.82	51.33	10.85	3.72	13,235	1,092
Gallatin	5	4.30	......	......	10.74	4.36	12,452	......	......	......	......	......	361
Grundy	2	14.69	......	......	6.97	3.09	11,276	......	......	8.17	3.62	13,217	733
Grundy	2	14.16	......	......	5.00	1.57	11,531	......	......	5.82	1.83	13,436	734
Logan	5	14.80	......	......	11.76	3.03	10,586	......	......	13.81	3.56	12,426	720
Macon	5	13.91	37.00	39.33	9.76	3.29	10,804	42.95	45.72	11.33	3.82	12,549	[1]1,569
Macoupin	5	12.17	......	......	10.61	4.81	10,805	......	......	12.87	5.48	12,303	737
Macoupin	5	12.75	......	......	9.73	4.26	10,829	......	......	11.13	4.89	12,414	736,735
Macoupin	5	12.80	......	......	10.40	3.78	10,847	......	......	11.90	4.33	12,440	738
Peoria	5	14.73	35.92	36.74	12.61	3.38	10,451	42.13	43.09	14.78	3.97	12,257	1,410
Peoria	5	13.45	34.81	37.32	14.42	3.09	10,398	40.22	43.12	16.66	3.58	12,014	1,409
Perry	6	10.37	36.88	40.27	12.48	3.52	11,018	41.14	44.94	13.92	3.93	12,293	1,614
Perry	6	9.87	38.29	39.35	12.49	2.96	11,051	42.46	43.68	13.86	3.28	12,261	1,615
Perry	7	9.31	......	......	13.33	0.89	11,047	......	......	14.71	0.98	12,181	421
Perry	7	11.03	34.06	43.58	11.33	0.90	11,079	38.27	49.10	12.63	1.01	12,453	1,523
Perry	6	11.11	35.82	38.94	14.13	3.86	10,542	40.29	43.82	15.89	4.34	11,859	1,591
Perry	6	10.49	38.57	40.04	10.90	3.44	11,064	43.09	44.74	12.17	3.84	12,361	1,592
Randolph	6	9.93	37.48	40.51	12.08	4.83	11,028	41.62	44.97	13.41	5.36	12,245	1,616
Randolph	6	10.72	36.63	39.65	13.00	4.53	10,694	41.03	44.42	14.55	5.07	11,978	1,610
Saline[1]	5	4.89	36.53	47.65	10.93	3.96	12,298	38.41	50.10	11.49	4.16	12,931	1,095
Saline[1]	5	4.34	35.79	47.75	12.12	5.85	12,321	37.41	49.91	12.68	6.12	12,879	1,110
Saline	7	5.73	......	......	11.19	3.13	12,177	......	......	......	......	......	360
and	7	5.98	35.22	45.84	12.96	3.51	11,757	37.46	48.75	13.79	3.73	12,505	1,120
White	7	6.71	36.75	45.81	10.73	4.16	11,889	39.39	49.11	11.50	4.46	12,744	1,121
Sangamon	5	14.96	......	......	9.38	3.87	10,747	......	......	11.04	4.55	12,640	722
Sangamon	5	13.71	......	......	10.82	3.62	10,691	......	......	12.61	4.19	12,392	741,740
Sangamon	5	13.56	......	......	9.29	4.13	11,019	......	......	10.76	4.78	12,749	540
Sangamon	5	14.39	......	......	11.68	3.95	10,534	......	......	13.64	4.61	12,304	721
Sangamon	5	13.14	......	......	10.62	4.36	10,746	......	......	12.23	5.03	12,372	739
Tazewell	5	14.30	36.74	39.11	9.85	3.34	10,875	42.87	45.64	11.49	3.90	12,690	1,412
Tazewell	5	14.35	36.95	38.04	10.66	3.02	10,709	43.14	44.41	12.45	3.53	12,504	1,413
Vermilion	6	12.96	37.26	42.79	6.99	1.55	11,580	42.80	49.17	8.03	1.78	13,304	558
Vermilion	6	12.56	36.92	42.52	8.00	1.23	11,418	42.25	48.60	9.15	1.41	13,058	557
White	..	See S	aline.										
Williamson	5	6.29	36.72	46.99	10.00	3.61	12,251	39.20	50.12	10.68	3.86	13,073	896
Williamson	7	9.69	32.11	48.96	9.24	1.05	11,810	35.56	54.21	10.23	1.16	13,077	1,613
Williamson	7	10.15	32.95	48.16	8.74	0.95	11,887	36.67	53.60	9.73	1.06	13,229	1,611
Williamson	7	6.12	37.56	43.40	12.92	4.15	11,698	40.02	46.22	13.76	4.42	12,461	1,612
Williamson	7	6.69	34.38	49.00	9.93	2.33	12,144	36.83	52.52	10.65	2.50	13,016	1,088
Williamson	7	9.50	......	......	9.16	1.02	11,836	......	......	10.13	1.12	13,078	460
Williamson	7	6.80	35.89	46.27	11.04	2.76	11,918	38.50	49.66	11.84	2.96	12,788	1,567
Williamson	7	9.99	......	......	7.63	0.92	11,992	......	......	8.48	1.03	13,323	459
Williamson	7	9.39	......	......	6.94	1.71	12,211	......	......	7.66	1.89	13,475	462

[1] At some distance from mines of Table III.

THE OCCLUDED GASES IN ILLINOIS COALS.

(By Perry Barker.[1])

Introduction.

In connection with the investigations on coal-deterioration conducted by the State Geological Survey and the Engineering Experiment Station of the University of Illinois, some determinations of the nature and amounts of occluded gases in Illinois coals have been made.

The first facts of importance in regard to these gases occluded or mechanically inclosed in the coals of Illinois developed when a number of fresh mine-samples were left tightly sealed for ten months. Upon opening at the end of this time, the gases in the containers ignited and burned with considerable flame.[2]

Description of Investigation.

In order to study the composition of the gases thus evolved, several samples were collected from fresh seam-faces in a similar manner and allowed to stand for seven months. They were then opened under water, and the gas surrounding the coal in the containers was collected by displacement. A similar set of samples was collected in jars which were filled with water, and whatever gas had been given off at the end of seven months was collected. The results of these two sets of analyses are given in Table I.

Table I.—*Occluded Gases in Illinois Coals.*

	I.	II.	III.	IV.	V.	VI.
Weight of coal, grams	642	800	648	800	787	800
Volume of gas, cc.,[3]	[4]446	38.8	[4]442	29.3	[4]331	97.8
Per cent by volume.						
CO_2	0	0	5.88	0	0.88	0
O	18.50	1.87	7.64	1.03	0	1.08
CH^4	0	55.97	0	35.39	11.83	90.28
N	81.50	42.16	86.48	63.58	87.29	8.64

I. Lebanon, Lebanon City Coal Co., sealed, dry.
II. Lebanon, Lebanon City Coal Co., sealed, submerged.
III. Bennett, Bennett Mine, International Coal Mining Co., sealed, dry.
IV. Bennett. Bennett Mine, International Coal Mining Co., sealed, submerged.
V. O'Fallon, Mine No. 2, St. Louis & O'Fallon Coal Co., sealed, dry.
VI. O'Fallon, Mine No. 2, St. Louis & O'Fallon Coal Co., sealed, submerged.

[1] Assistant Chemist Engineering Experiment Station.
[2] Trans. Amer. Ins. Min. Eng., xxxviii, 630 (1908).
[3] At normal temperature and pressure.
[4] Total gas from containers.

It is evident that aside from the addition of methane and carbon dioxide to the ordinary constitutents of air, a decrease in the percentage of oxygen originally contained in the air of the jars had taken place. In order to test the extent of this absorption of oxygen, a number of samples of coal were placed in jars with large volumes of air. These samples were portions of the series that had been sealed for ten months and later had been partly air-dried. Table II shows the general nature of this change.

TABLE II.—*Occluded Gases in Illinois Coals.*

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Weight of coal, grams	109	139	180	183	146	134	138	153
Volume of gas, cc.,[1]	873	849	816	814	843	853	850	837
Per cent by volume.								
CO_2	0.48	0.94	0.68	1.87	0.25	1.23	1.11	1.62
O	0.16	0.13	0	0	0.25	0	0	1.45
CH_4	0	0	6.28	0	2.17	0	0	0
N	99.36	98.93	93.04	98.13	97.33	98.77	98.89	96.93

I. Springfield, Sangamon Mine, Sangamon Coal Co.
II. Springfield, Sangamon Mine, Sangamon Coal Co.
III. Eldorado, Mine No. 8, O'Gara Coal Co.
VI. Marion, Chicago & Big Muddy Coal Co.
V. Herrin, Squirrel Ridge Mine, Chicago & Carterville Coal Co.
VI. Duquoin, Greenwood, Davis Coal Co.
VII. Belleville, Suburban Coal Mining Co.
VIII. O'Fallon, Mine No. 2, St. Louis & O'Fallon Coal Co.

The two sets of analyses in Tables I and II give some indication of the nature of the alterations that are going on when coal is exposed, but give no information as to the composition of the gas remaining in the coal. Moreover, the samples were of various sizes of coal that had been broken from the face of the seam, and they had been exposed, even if only for short periods. In order to get coal closely representative of the material as it occurs in the seam, a set of samples of drill-dust were collected in the following manner: As the drillings fell from the hole, they were collected in an ordinary half-liter fractionating-flask fitted with a stop-cock at the side tube. When the flask was filled, it was sealed with a rubber stopper which was coated with a rubber-resin vacuum cement. These flasks were taken to the laboratory as soon as possible, and all the gases contained therein were removed by means of a mercury air-pump, and collected over mercury. The flasks were then allowed to stand for several days, after which they were again connected with the air-pump, and any gas that had been evolved was removed.

In order to have some extreme types of laboratory-weathered samples to compare with the fresh drillings, a set of coals that had been used for some previous tests were evacuated in the above manner. These were portions of mine-samples about two years old, which had been quar-

[1] At normal temperature and pressure. Total gas from containers.

TABLE III.—*Occluded Gases in Illinois Coal.*

Last portions of air.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Time of standing, days	7	9	14	2	13	4	13	6	7	1
Weight of coal, grams	261	209	220	205	244	204	217	204	231	108
Volume of gas, cc,[1],	141.2	96.6	192.1	33.5	287.4	40.6	160.6	63.3	197.2	38.4
Cc. of gas per 100 g.,[2]	54.21	46.2	87.32	16.37	117.8	19.91	74.00	30.97	85.50	35.55
CO_2	2.12	1.91	3.37	1.27	6.55	1.23	3.27	0.54	10.34	0
O	2.87	2.06	0.94	2.54	0.58	2.75	0.95	5.04	0.95	7.90
CH_4	12.22	0	19.01	0	38.22	0	1.57	0	19.81	0
N	37.00	42.23	64.05	12.56	72.45	15.93	68.21	25.39	54.40	27.76
Per cent by volume.										
CO_2	3.92	4.15	3.86	7.80	5.56	6.20	4.43	1.79	12.09	0
O	5.30	4.46	1.04	15.50	0.49	13.80	1.28	16.25	1.11	22.20
CH_4	22.53	0	21.79	0	32.44	0	2.12	0	23.17	0
N	68.25	91.39	73.31	76.70	61.51	80.0	92.17	81.96	63.63	77.80

Gas removed by vacuum.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Time of standing, days	13	8	12	10	13	12	13	11	13	10
Weight of coal, grams	261	209	220	205	244	204	217	204	231	108
Volume of gas, cc.,[1]	26.9	14.9	48.8	1.9	76.4	5.8	20.4	20.5	26.0	1.1
Cc. of gas per 100 g.,[2]	10.31	7.11	22.18	0.93	31.30	2.84	9.4	10.04	11.26	1.02
CO_2	1.84	5.74	1.68	......	4.63	0.69	3.18	2.01	3.51	0.56
O	0.50	0.10	0.14	......	0.29	0.15	0	0	0.82	0.10
CH_4	6.14	0	19.15	......	22.20	0	0.09	0	2.17	0
N	1.83	1.27	1.21	......	4.18	2.00	6.13	8.03	4.76	0.36
Per cent by volume.										
CO_2	17.85	80.50	7.58	......	14.79	24.20	33.84	20.0	32.09	54.60
O	4.83	1.30	0.61	......	0.92	5.90	0	0	7.32	9.90
CH_4	59.59	0	86.37	......	70.93	0	1.00	0	19.26	0
N	17.73	18.20	5.44	......	13.36	69.90	65.16	80.0	41.33	35.50

I. Springfield, Sangamon Mine, Sangamon Coal Co., drillings.
II. Springfield, Sangamon Mine, Sangamon Coal Co., face-sample, 2yr. old.
III. Herrin, Squirrel Ridge, Mine, Chicago & Carterville Coal Co., drillings.
IV. Herrin, Squirrel Ridge Mine, Chicago & Carterville Coal Co., face-sample, 2yr. old.
V. Clifford, Mine No. 8, Big Muddy Coal & Iron Co., drillings.
VI. Clifford, Mine No. 8, Big Muddy Coal & Iron Co., face-sample, 2 yr. old.
VII. Marion, Mine No. 3, Peabody Coal Co., drillings.
VIII. Marion, Mine No. 3, Peabody Coal Co., face-sample, 2 yr. old.
IX. Westville, Mine No. 44, Dering Coal Co., drillings.
X. Westville, Mine No. 44, Dering Coal Co., face-sample, 2 yr. old.

[1] At 0° and 760 mm. pressure.
[2] Figured to coal as sampled.

tered, reduced to buckwheat-size, and air-dried. These two series correspond as to location of the mines, so that comparison of the changes in the occluded gases can be made by inspection of Table III.

The striking feature of the analyses in Table III is the large loss of combustible gases by the fresh drillings. While this amounts to as much as 30 cc. per 100 g. in the fresh samples, no such gases were detected in the old lots. However, it must be understood that the relative amounts of gas in coal from these various mines cannot be critically judged from these analyses, as some of the working-faces had been within short distances of long-standing exposures. (A universal shut-down in the Illinois coal mines during April and a part of May, 1908, made it impossible to get samples representative of continuous workings.) Some idea of the rapidity of transpiration of occluded gases from exposed faces can be gathered from the following data.

As a drill-hole was driven, the dust from the first 2.5 feet was collected in one flask, while that from the last three feet was sealed in a separate container. As can be seen in Table IV, the sample farther from the exposed face contained more occluded gas and had less changes produced in what did remain.

Table IV.—*Occluded Gases in Illinois Coal.*

	I.	II.	III.	IV.
Time of standing, days	7	7	13	13
Weight of coal, grams	182	231	182	231
Volume of gas at 0°C., 760 mm	174	197.2	9.6	26.0
Cc. of gas per 100 g	95.30	85.47	5.27	11.26
CO_2	7.21	10.34	1.76	3.51
O	0.59	0.95	0	0.82
CH_4	11.28	19.81	2.30	2.17
N	76.22	54.37	1.21	4.76
Per cent by volume.				
CO_2	7.57	12.09	33.33	32.09
O	0.62	1.11	0	7.32
CH_4	11.73	23.17	43.74	19.26
N	80.08	63.63	22.93	41.33

I. Westville, drillings from first 2.5 ft. of hole, last air.
II. Westville, drillings from last 3 ft. hole, last air.
III. Westville, drillings from first 2.5 ft. hole, gas by vacuum.
IV. Westville, drillings from last 3 ft. of hole, gas by vacuum.

In addition to the loss of combustible gases, the drill-samples showed more extensive absorption than did the laboratory-weathered ones. From this it may be concluded, either that the oxygen has entered into some combination with the coal itself, or that a reaction has taken place, resulting in the formation of carbon dioxide. The presence of considerable amounts of carbon dioxide in the gases from the fresh samples

seems to bear out the latter conclusion, although this gas does not completely replace the oxygen of the air. It may also be possible that the carbon dioxide formed and taking the place of the occluded gases is only given off at higher temperatures. That this is true to some extent is shown by the fact that 69 per cent of the gases removed from one of these fresh samples at 100° C. consisted of carbon dioxide.

It is certainly true that this absorption of oxygen takes place as soon as the gases escape from the fresh coal. A study of some of the stages of this absorption or oxidation can be made from Table V. In this table all samples were from the same mine. Nos. I and II were partly air-dried face-samples about two years old. From No. 1 the surrounding air in the container was collected by displacement and analyzed. No. II was left in one of the sealed fractionating-flasks for two days. At the end of that time both the surrounding air and some of the inclosed gases were removed by means of the air-pump. No. III is a flask of drillings from which the surrounding air and occluded gases were removed as above. No. IV is the analysis of the gas given off after the surrounding air had been removed and the flask had stood in a vacuum for twelve days. No. V is the analysis of the air that had been admitted to the evacuated flask and left in contact with the coal for seven days.

The preceding results give some light upon the changes produced by the deterioration of sealed laboratory-samples, but contain no data as to samples subjected to outside exposure. Table VI gives a comparison between samples of fresh drillings and samples exposed to the weather. No. I is a sample of drillings from Westville, while No. II was collected off the surface of a pile of the same screenings fifteen months old, and No. III is a sample of the same screenings that had been stored outside

TABLE V.—*Occluded Gases in Illinois Coal.*

	I.	II.	III.	IV.	V.
Weight of coal, grams	146	20.5	220	220	220
Volume of gas, cc	843	33.5	192.1	48.8	130.4
Per cent by volume.					
CO_2	0.25	7.80	3.86	7.58	1.63
O	0.25	15.50	1.04	0.61	0.37
CH_4	2.17	0	21.79	86.37	14.14
N	97.33	76.70	73.31	5.44	83.86

I. Old face-sample in contact with large volume of air.
II. Old face-sample sealed 2 days.
III. Dri.lings, sealed 14 days.
IV. Drillings, in vacuum 12 days.
V. Drillings, second air in contact with coal 7 days.

TABLE VI.—*Occluded Gases in Illinois Coal.*

Last portions of air.

	I.	II.	III.	IV.	V.	VI.	VII.
Time of standing, days	7	3	6	13	19	7	3
Weight of coal, grams	231	200	200	217	224	261	200
Vol. of gas, 0°C., 760 mm	197.2	44.2	55.8	160.6	134.3	141.2	240.5
Cc. of gas per 100 g	85.50	22.10	27.9	74.01	60.0	54.21	120.25
CO_2	10.34	1.40	0.25	3.27	3.38	2.12	3.03
O	0.95	3.25	5.75	0.95	0.38	2.87	22.09
CH_4	19.81	0	0	1.57	0.54	12.22	0.66
N	54.40	17.45	21.90	68.22	55.70	37.00	94.47
Per cent by volume.							
CO_2	12.09	6.34	0.90	4.43	5.64	3.92	2.51
O	1.11	14.71	20.61	1.28	0.64	5.30	18.36
CH_4	23.17	0	0	2.12	0.54	22.53	0.55
N	63.63	78.95	78.49	92.17	93.18	68.25	78.58

Gas removed by vacuum.

	I.	II.	III.	IV.	V.	VI.	VII.
Time of standing, days	13	14	13	13	7	13	13
Weight of coal, grams	231	200	200	217	217	261	200
Volume of gas, 0°C., 760 mm.	26.0	26.9	16.8	20.4	19.3	26.9	23.9
Cc. of gas per 100 g	11.26	13.45	8.4	9.40	8.88	10.31	11.95
CO_2	3.51	1.4	2.85	3.18	2.99	1.84	2.39
O	0.82	2.8	0.7	0	0.36	0.50	0.81
CH_4	2.17	0.15	0.6	0.09	0.10	6.14	2.39
N	4.76	9.10	4.25	6.13	5.43	1.83	6.36
Per cent by volume.							
CO_2	32.09	10.41	33.93	33.84	33.67	17.85	20.00
O	7.32	20.82	8.33	0	4.02	4.83	6.78
CH_4	19.26	1.12	7.15	1.00	1.05	59.59	20.00
N	41.33	67.65	50.59	65.16	61.26	17.73	53.22

I. Westville, Mine No. 44, Dering Coal Co., drillings.
II. Westville, Mine No. 44, Dering Coal Co., screenings, 15 months old.
III. Westville, Mine No. 44, Dering Coal Co., screenings, 2 months old.
IV. Marion, Mine No. 3, Peabody Coal Co., drillings.
V. Marion, Binkley, Miles Co., outcrop coal.
VI. Springfield, Sangamon Mine, Sangamon Coal Co., drillings.
VII. Springfield, Sangamon Mine, Sangamon Coal Co., screenings, 2 months old.

for two months. No. IV is a sample of drillings from Marion, while No. V is from an outcrop of the same seam one mile from the place where No. IV was taken. This outcrop had been exposed for one year. No. VI is a sample of drillings from Springfield, while No. VII was collected from the surface of a pile of 1.5-inch screenings from the same mine. These screenings had been stored outside for two months.

CONCLUSIONS.

The conclusions drawn from these investigations may be summarized as follows:

1. Loss of combustible gas begins as soon as pressure upon the coal in the seam is released and air is brought into contact with the newly exposed surfaces.

2. As soon as the gases occluded by the coal are released, an absorption of oxygen from the atmosphere begins. The oxygen may enter the coal substance and combine with it or may unite with carbon to form carbon dioxide.

3. Carbon dioxide is undoubtedly formed to some extent by the action between the coal and whatever oxygen it has already absorbed.

4. Upon outside exposure, coal loses most of its occluded gases and even a large part of the carbon dioxide formed by the absorption of oxygen.

Experiments at higher temperatures will be conducted in order to determine, if possible, more exactly the changes that are produced when coal deteriorates, and to throw some light on the cause of spontaneous combustion.

MINING-WASTES AND MINING COSTS IN ILLINOIS.

(BY GEORGE S. RICE.[1])

INTRODUCTION.

In coal mining operations throughout the State of Illinois there is a greater range in the amount of coal extracted from a given volume of coal-seam than might be expected from the remarkable uniformity in thickness of the chief seams. The percentage of yield varies from about 50 to 95 per cent, or more. The latter high yield is obtained in the long-wall mines of northern Illinois, embracing the Wilmington and the so-called "Third Vein" fields. The coal-seam mined in these two districts is the same geologically—the No. 2 of the Worthen Survey. The lowest yield is from the thick, more deeply buried, "Blue Band" seam of central and south central Illinois, in some localities termed "No. 5," in others "No. 6," and elsewhere "No. 7."

The variation in yield from the total amount of coal under a given land-surface is still greater, for in the thick-seam districts there are usually other seams than the one worked that it is possible, physically, to work. These are, in many cases, rendered more or less unworkable, when the distance between the seams is small, by being undermined.

CAUSES OF MINING-WASTE.

GENERAL.

The influencing conditions causing the great losses that are at present incurred are:

1. Cheapness of "coal in place;" that is, in the seam.
2. Low market prices, resulting from extreme competition.
3. Character of the seam, roof, and floor as determining the method of mining.
4. Surface-subsidence due to mining.
5. Interlaced boundary ownerships.
6. Carelessness in mining operations.

The first two factors, taken together, are the controlling ones in most mining operations in influencing the choice of a mining system. The majority of Illinois operators are sufficiently progressive to find ways and means to take out practically all the coal under a given area if it could be made evident that it paid to do so. That many do not do all that can be done in this direction is apparent; but if, without unusual investment, a profit of operation could be shown in taking out all the

[1] Consulting Engineer, Chicago.

coal over the profit made by present methods, the industry could undoubtedly find men to accomplish the task. In other words, from an engineering standpoint practically all the coal under a given area can be taken out. It is a question of cost.

CHEAPNESS OF COAL IN PLACE.

This is chiefly due to the great abundance of coal. Except in the barren northern one-fourth of the State, lying north of the outcrop of the coal-basin, the development of a tract depends primarily not on the possibility of finding coal in that particular locality, but on the question whether it is a suitable place, from a market standpoint, to open a mine, the thickness of seam and the quality of the coal being considered.

The price of coal-rights varies from $10.00 per superficial acre in the middle part of Illinois, away from the mining centers, to $100.00 per acre near developed mines. Or, in the case of leasing, from two cents per ton run-of-mine hoisted, in the southern part of the State, to five cents in the northern part. The cost of the fee is relatively so much cheaper per ton than leasing that the latter system is not much used. The ownership of the coal by the operator is conducive to better mining, but relative to other items that go to make up the total cost, that of the "coal in place" is so low as to be almost negligible. In central Illinois, in some cases, as a cost of only $10.00 per acre, two workable seams, from 6 to 8 feet thick, are obtained. Allowing only 50 per cent yield of the two seams, 13,000 tons would be produced per acre, the purchase cost thus being 1/13 of a cent per ton, or about 1/1000 of the total cost of production in central Illinois. In the Wilmington long-wall field the average cost of the coal-rights is about $50.00 per acre. The seam there, although it averages a trifle less than three feet in thickness, produces about 5,000 tons per acre. The cost is therefore about one cent per ton in place, which is 0.75 per cent of the total cost of production. Hence, it may be seen there is little incentive, from the standpoint of the purchase-price of the coal, to save the latter in mining operations.

LOW MARKET PRICES.

The tremendous development of the coal-carrying railroads and the policy of making low ton-mile rates for long hauls has resulted in excessive competition, both from within and from without the State. The cheaply produced coals of the eastern states, and particularly West Virginia, resulting from favorable natural conditions and lower labor-cost, with through low freight-rates, have enabled them to enter the natural coal markets of Illinois and sell at prices very little above what the Illinois coals bring. The high quality of these coals, particularly those that make little smoke, has allowed them to set the pace in making prices.

The competition between the Illinois coals has been even more severe. This results from the multiplicity of ownerships, due mainly to the ease of opening new mines. Each period of unusual prosperity in the western coal business, like that at the time of the anthracite strike, is followed by an immense increase in capacity. For example: In 1906 and 1907

railroad shipping mines operated an average of 190 and 195 days, during the respective years, out of 300 working days; in other words, only 63 and 65 per cent of the time (See Figs. 2 and 3). To a certain extent this is unavoidable, as the markets are in a climate of extreme cold in winter, and as the Illinois coal stocks very indifferently, the winter demand tends to fix the capacity. This, in turn, makes the labor-rates high, to cover the period of idleness. On the other hand, it makes severe competition during the spring and summer months, in the effort of each operator to keep his mine running as much as possible.

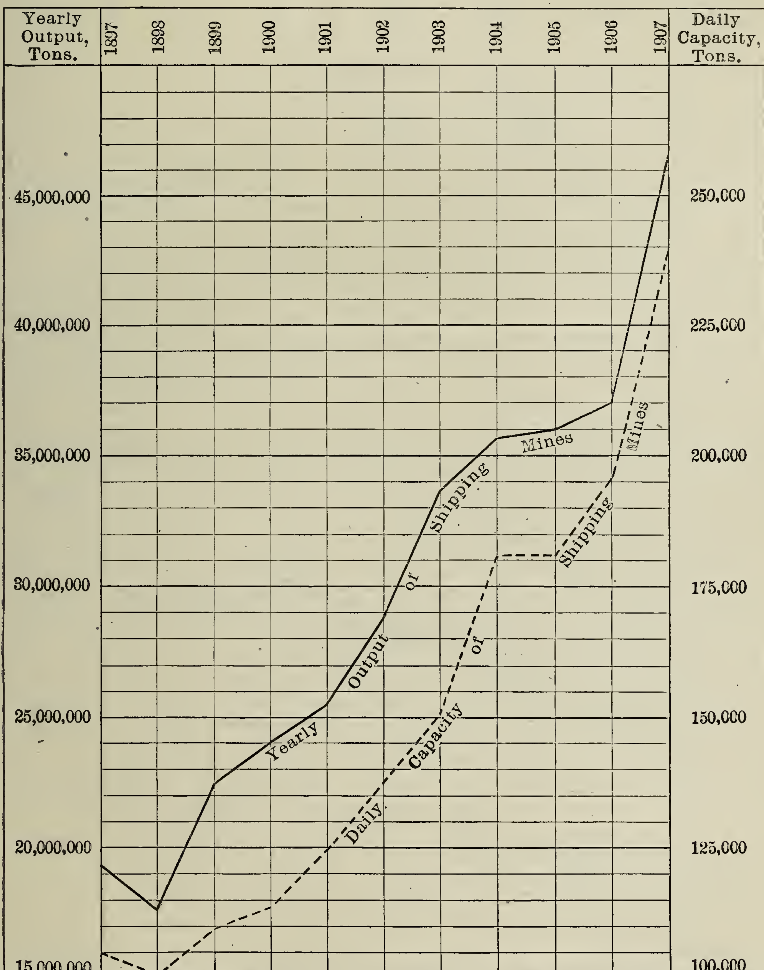


FIG. 2.—Illinois Shipping Mines; Yearly Output of Coal, Also Daily Capacity for a Period of 10 Fiscal Years.

The annual coal report of Illinois for 1906, compiled by the Bureau of Labor Statistics, gives as the average value, or selling price, per ton, of all sizes on cars at the mines in northern long-wall districts, $1.41;

in the "shooting-coal" districts, from $0.866 to $1.153; and for the whole State, average, $1.029. As the State treats the individual mine returns as confidential, the figures given are generally regarded by operators as essentially correct. The average hand-mining rates for the long-wall districts are $0.754 and $0.784, and of the "shooting-coal" districts from $0.458 to $0.609. The underground hauling, timbering, brushing, hoisting, top-labor, and supplies must be added to the foregoing figures to obtain total operating costs. The average total cost per ton of coal

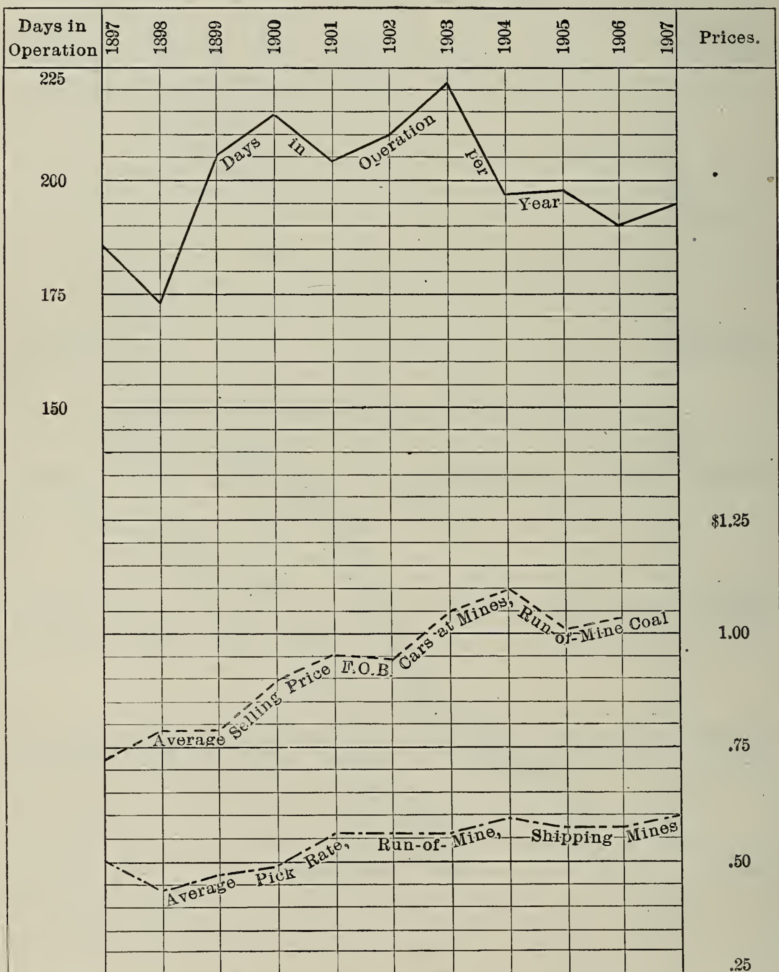


FIG. 3.—Illinois Shipping Mines: Days in Operation, Average Value, and Pick-Rate, Yearly, for a Period of 10 Fiscal Years.

loaded on cars, including general and selling expense and amortization, but not capitalization interest charges, is from $1.20 to $1.30 for the coal produced in the long-wall districts, and from $0.70 to $0.95 for the other districts. It is safe to say that the average net profit per ton

throughout the State for a whole year does not exceed 20 cents, and if the interest on the capital be taken out, the average profit will be reduced to 10 or 15 cents per ton; actually the average profit is probably less than these figures.

It will therefore be seen that, with the small margin of profit, there is little incentive for the individual mine operator of either Illinois or elsewhere to conserve, beyond customary good practice, the coal he owns or leases.

CHARACTER OF SEAM, ROOF AND FLOOR AS DETERMINING THE METHOD OF MINING.

It is the system of mining adopted that determines the proportion of coal won in a given seam. Where the long-wall system can be physically and commercially used, the problem is solved, for in a well handled long-wall mine the only loss of coal is in the fine particles, which become mixed with the fire-clay and roof-dribblings and get shoveled back into the gob. Probably not more than two per cent is lost in this way.

Under the ordinary long-wall conditions of northern Illinois, falls of roof, especially during periods of idleness, local carelessness in leaving "points" or projections of the face, and abandonment of corners in the ownership of the land cause additional losses. In one mine, at which a record was kept for a period of six years, the total loss of coal from all causes was five per cent.

About 5,300,000 tons were produced in 1906 by long-wall mines, nearly all in the Wilmington and the Third Vein districts, at the north end of the Illinois field. The output of these districts has been practically stationary for some years, owing to the competition of eastern coals and of the thick-seam coals of middle and southern Illinois. Long-wall is the only system that can be successfully used in the No. 2 seam, as found in the northern districts. Briefly, the conditions are these:

A blocky coal when mined by undercutting, but tender and flying to pieces when "shot" down; a "soapstone" (shale) roof without fissure-cracks, until such are formed by the successive settlements caused by the undercutting; a clay under the coal that generally presents fairly easy cutting; and a harder sandy clay floor which causes the coal and under-clay to break or work, when the roof "weight" is properly thrown on the long-wall face, by systematic building of pack-walls and keeping the faces aligned. Finally ,the mines, with one or two exceptions, are dry.

In the larger part of the Illinois field the "advancing long-wall" of the northern "thin-vein" field is not practicable. The roof is generally too hard to "break" properly, and there is generally no "draw-slate" to make buildings with. The other conditions, clay mining and dry work, are all right, but the former are obstacles to "advancing" long-wall, without the extraordinary expense of importing stone for pack-walls. The several workable seams are considered below in order.

No. 1 of the Worthen Survey is not generally identified throughout the State. Coal worked in the vicinity of Rock Island is called No. 1. It occupies channels and local depressions cut into the shale previously

laid down on the Burlington limestone. It seems likely that this coal may belong to a later period than the shaly seam which quite regularly underlies the No. 2 seam in the Wilmington and Third Vein districts. The system of mining this seam is the ordinary room-and-pillar method, the pillars in some cases being withdrawn. The yield is from 65 to 70 per cent of the territory covered by the entries. The channels are usually narrow and the coal thins along the margin, so that all coal, less than about 3 feet thick, is lost. As a whole, No. 1 seam has little commercial importance in the State.

No. 2 is a remarkably persistent seam, apparently extending throughout the whole of the Illinois basin. It varies from 1.5 to 4 feet in thickness. While a high-grade Illinois coal, the cost of production makes it commercially available only in the northern field, where it is extensively opened, as already described, by long-wall mines. Elsewhere there are large areas of this seam, running from 2 to 2.5 feet in thickness.[1] While this is too thin to work at present, it is not underlain by valuable coal, and hence will not be damaged by any mining operations below it, but will remain as a reserve and problem for future operators.

Nos. 3 and 4 seams are not well-defined horizons and are practically negligible, so far as at present known.

No. 5 is an important seam. It has been extensively developed in Fulton county and in the Springfield district, where it shows great uniformity. In the central and southern part of the coal basin it is not clearly defined. Its characteristic feature is the presence of clay-slips running irregularly through the coal, and indicating shattering, with subsequent filling. It has a strong slate roof, which is more or less sandy, and presents a pebbly, knobby surface when exposed in the roof; usually there is a "draw-slate" between roof and coal, which is in some places strong enough to be held up by timbering. The coal itself is clean. The irregular clay-slips, "horses," and sulphur-balls are frequent but are separable. The floor is a shale, which exfoliates when exposed to the air.

In the Fulton county field this seam is from 4 to 5 feet thick and remarkably even. It is mined by the room-and-pillar system. As it is shallow, the pillars are left very small, and, in general, are not pulled. A great deal of coal in the vicinity of the outcrops is rendered unworkable by nearness to valleys filled with glacial drift. Within the workable areas the yield by the present methods is from 60 to 65 per cent of the coal in place.

In the Springfield district, No. 5 is from 5 to 6 feet thick. The room-and-pillar system is employed. Some pillars are drawn, but generally the clay-slips and "horses" are so frequent that an effort is made to lay out the pillars to include them. On the whole, the yield is about the same as in the Fulton county field. South of Springfield, and in the Third Vein district, No. 5 coal is more pockety. As it is from 160 to 190 feet above seam No. 2, and as the latter is worked only long-wall, the unworked areas will not be damaged by working out the lower seams.

No. 6 is the great producing seam of the State. Except for a few developments in northern Illinois, in Bureau county, the mines work-

[1] EDITOR'S NOTE—This seam is commercially worked also at Murphysboro in Jackson county.

ing it are in central and southern Illinois. The seam lies from 40 to 60 feet above the No. 5 horizon. It is characterized by a "blue band," which occurs from 2 to 4 feet above the bottom. The seam is from 5 to 9 feet thick. The Virden-Mt. Olive seam and the Duquoin-Ziegler seam both belong, in my opinion, to the "Blue Band" seam. The seam in the former district has generally been called No. 5, although drilling indicates a pockety seam below it at the No. 5 horizon. The State Geological Survey's recent investigations, I am informed, show that the Herrin seam in Williamson county, heretofore called No. 7, also belongs to the No. 6 horizon.

The main roof of the "Blue Band" seam is a limestone, usually with a shale or clay layer, 1 foot to 4 feet thick, between it and the coal. In some places the limestone comes down to the coal, in others it disappears entirely. In all cases the main roof is very strong, and this has an important bearing on the system of mining adopted. The coal is usually a brighter, cleaner coal in itself than the No. 5 coal, but in central Illinois it has a large amount of "sulphur" (iron pyrites) in balls, lenses, and stringers. The coal, and locally, the roof of this seam, contains considerable marsh gas in the more deeply buried portions. The floor is a clay containing, below the mining, many "nigger-heads." This clay readily "squeezes" when subjected to pressure, as when pillars are too small. The main roof is very difficult to "break," so that, when the coal is from 350 to 600 feet or more deep, it is very essential to leave large pillars. Many mines, in other ways well systematized, have had serious difficulty from "squeezes" brought on by leaving too-thin pillars or robbing them. The older mines were all opened on the room-and-pillar plan. Lately, the majority of the mines have been changing to the "panel" system with beneficial results, but as yet no systematic attempts have been made to pull pillars. The result is, that in the deeper mines only one-half of the coal is secured, taking into account barrier as well as other pillars.

As a whole, there is taken out of this seam only from 50 to 60 per cent of the coal it contains, the gross quantity of which throughout the State certainly exceeds the contents of any other seam, and possibly of seams Nos. 5 and 7 together. It is the seam now most actively worked, and will continue to be the most productive; but its exploitation involves the largest losses, and hence calls for the most earnest study in the interest of great economy. The coal, when freed from impurity, is a very strong steam-coal, and the seam tends to improve in quality as well as thickness in going south.

No. 7 is not generally present in northern Illinois. If it ever was so, it has been generally eroded. Outside of the Danville district, it certainly does not exist as a thick seam. In that district it is known as the "Danville seam." The Grape Creek seam, which is below it, and in which there has been the greatest development, is considered to be No. 6. The correlation of these various seams by the State Survey is looked forward to with great interest. As mined at Danville, No. 7 is from 5 to 7 feet thick. It has been opened up by the usual room-and-pillar system, and the pillars are not drawn. Owing to the numerous slips and poor roof the yield is low, probably but little over 50 per cent.

There have been no workable seams discovered above the No. 7. Here and there in the upper part of the deep sections of the measures in the central part of the basin, as found by drilling, there are seams 1 to 2 feet in thickness, but the time is very remote when they can be made available.

THE SURFACE SUBSIDENCE DUE TO MINING.

The influence of this factor upon the yield results from the high value of Illinois lands for agricultural purposes, well improved, tiled land being worth from $100.00 to $175.00 per acre. In mining coal by the long-wall system, where the overlying surface is flat, the tile-drains are deranged and swampy places are made, although the surface may sink only from 1.5 to 2 feet. This is particularly the case in the Wilmington district. In the LaSalle district the ground is more rolling and the subsidence has little effect. Although the goaves in the mines of these districts are supposed to be nearly filled, in reality they are not, and the settlement is practically one-half the thickness of the seam. If the long-wall system were applied to the thick seams, when applicable at all, it would cause a considerable derangement of the surface, and where the latter is so nearly level as the prairie-land of central Illinois, it makes the question of subsidence a serious one. It may be solved to a certain extent through draining the sunken lands by pumping, but even with such a method, aside from the expense, there is a serious difficulty from storm water. When the subsidence of the surface is from 2 to 4 feet it will render previously level lands of little use for raising crops until the particular area has come to full settlement and has been retiled. The same is true if all the coal be taken out by any other system, and is even more emphasized where no pack-walls are used, because then the subsidence is practically the full thickness of the seam. If it were possible to systematize mining so that the land nearest the water courses was first undermined and then in succession the land further away, the damage done to farming would be minimized. However, until the agricultural land in the United States becomes insufficient to fill the needs of the population, which would be reflected in a continual increase of price for farming land, the money loss from temporarily destroying the surface in places is relatively small, as compared with the selling-price of the coal mined under the seam. Taking the average value of the surface at $125.00 per acre, if 80 per cent be rendered worthless, the immediate money-loss would be $100.00 per acre. A seam 6 feet thick would contain per acre 11,000 tons of coal in place, yielding, at 90 per cent, 9,900 tons. The damage done by practically destroying the surface would be only 1 cent per ton. If the land prices should rise two or three times above the value stated, this loss would still not prohibit mining.

INTERLACED BOUNDARY OWNERSHIP.

The losses in mining arising from this factor have been perhaps less important in the past than they may be in the future. I had occasion some time ago to examine a property where there was coal within a

quarter of a mile of the shaft on either side, yet the operator was obliged to mine coal at a distance of one and a half miles. Some of that near the shaft could not be purchased, yet it lay in such a way near a geological uplift that it would not pay to open another mine to reach it. A number of such instances can be found. There have been large purchases, by various corporations, of coal-rights through Illinois, which have been taken up checker-work fashion, and unless the State interposes its authority it is conceivable in some cases that coal may be lost through improper development due to adverse ownership. Such effects, in a number of cases, have been avoided by adjoining owners getting together and trading to form areas suitable for the layout of individual mines.

CARELESSNESS IN MINING OPERATIONS.

Losses from this source have been very great. They may be set down under these heads:

1. Improper system of mining.
2. Carelessness in following any system of mining by which blocks of coal are lost, and, where pillars are being pulled, carelessness in failing to systematize the work, so that "squeezes" will be avoided. The same is true of advancing work, where improper proportioning of pillars or alignment of roads has brought on "squeezes."
3. Inadequate surveys, records and maps, so that, with change of underground management, there has been a failure to give proper notice of pillars and blocks of coal that temporarily have been passed by.
4. An entirely inadequate system for filing maps and survey records of abandoned mines with either the county or the State. The absence of definite knowledge compels new adjacent mines, as a matter of safety, to keep farther away from an old abandoned mine, which may be full of water or gas, than would be necessary. At present it is impossible to find any map of a mine abandoned some years back. There is also insufficient attention paid to compelling operators of mines that are about to be abandoned to bring up the mine Surveys in a careful manner. In my opinion, the preservation of mine maps is properly a function for the State, as it is now for a county to record deeds, and there should be a permanent bureau established for the proper recording of the Surveys and maps of abandoned mines. This bureau also should take charge of and systematically file the maps of "going" mines.

REMEDIES FOR WASTE IN MINING.

POSSIBLE SAVING.

I believe it is possible to take out from 90 to 95 per cent of the coal under a given area, even if the character of the roof is such that pillars cannot be pulled and the advancing long-wall system is not applicable; that, in general, this can be done at an additional cost which need not make it prohibitive. In fact, taken over the whole life-time of the mine, it may be a profitable operation.

Where advancing long-wall can be used, it is plainly the most direct system to apply, but, as already observed, it is inapplicable in Illinois, in most cases, outside of the No. 2 seam.

FILLING SYSTEM.

Two general systems suggest themselves, one of which is a replacement with material sent down from the surface. This method is more or less employed in the anthracite district of Pennsylvania, where the culm-bank is used for the filling. It is also used extensively in Silesia. In Illinois, the substitute would have to be surface-sands and gravel. That this would be impracticable in the great majority of cases throughout the State is self-evident, particularly if water, the usual vehicle for transportation, is employed, inasmuch as the majority of the thick seams in Illinois have clay under them which water would soften and thus tend to cause a "squeeze." Aside from this, much farm land would be destroyed in getting the filling material.

RETREATING LONG-WALL.

The other system is driving to the boundaries of the property and then using either retreating long-wall or semi-long-wall systems, such as have been extensively developed in England. One or the other of these systms, in my opinion, could be applied in almost all cases, meeting the obstacles of strong roof and clay floor. The difficulties of a retreating system are these: The delay in getting an output, the increase in capitalization, and the added cost in the early stages of the mine, due to the increased capitalization. The off-set would be the saving of the coal; but this is a minor item of expense, and is balanced by the damage to the surface.

Estimates of Costs.—Taking a theoretical case, the figures would be about as follows: Let us assume, in the "Blue Band" seam of central Illinois, coal averaging 7 feet in thickness and 400 feet deep; shafts in the center of a group of four sections of land (2,560 acres); a mine equipment costing $125,000; townsite, coal-rights and miscellaneous outlays as much more; making a total capitalization of $250,000. Assume a pair of entries to be driven to the middle of one side of the property, thence to a corner, with additional stubs, making a total of about 8,000 yards of single entry. The use of machinery for driving the entries is presupposed, both for the sake of speed and for the advantage of the under-cutting, which allows the coal to be blasted down with small charges. Hence, three shifts could be used. Assuming an average advance of five yards per day, the cost would be roughly about $10.00 per yard in excess of the value of the coal produced. This would make a total charge of $80,000 in excess of the ordinary cost of development. At a speed of five yards per day it would take about 800 working days to drive the pair of entries the two miles to the corner, plus some stubs. Allowing for the inevitable delays this would mean 2.5 years to get to the same stage of development ordinarily reached when the main and

escape shafts have reached coal and have been connected underground. Allowing six per cent per annum for half the period (1.25 years), the interest on $80,000 would be $6,000. Possibly the expenditure of $50,-000 of the entire plant and town-site investment previously mentioned could be deferred till the final period of development. If so, $200,000 would be drawing interest for two years and six months—say at six per cent per annum. We then have:

Excess cost of 8,000 yd. entry complete	$80,000
per cent interest on $80,000 for 1 year and 3 months	6,000
per cent interest on $ 200,000 for 2 years and 6 months	30,000
Total excess cost of special development over that of ordinary development	$116,000

Hence, this additional amount of capital would be required. At six per cent the interest on $116,000 will constitute an annual charge of $6,960. If the theoretical plant has an annual average output of 300,000 tons, which would be normal for a commercial mine for the investment mentioned ($250,000), this fixed annual charge would amount to 2.32 cents per ton hoisted.

The cost of mining at the face, under the present labor contracts, would probably be the same as it is under the prevailing system. The cost of hoisting, dumping, and loading would also be the same, but at the start certain other items would be greater; the "care of mine" cost, due to the keeping up of the first long roads, would be larger than at any subsequent period. The same would be true of haulage; it has been assumed that an electric haulage for the two miles (four miles round trip) over what would be merely "gathering" in the conventional starting of a mine, at the center of the property, and which would be similar to the development at the corner of the property, should be between 4 and 5 cents per ton, considering labor, fuel, repairs, and sinking fund for the haulage plant.

During the life time of the mine this cost would be constantly decreasing, instead of increasing, as in the conventional advancing mine. The average over the whole period would be practically the same. In the "care-of-mine" cost, however, the average during the whole life time of the mine should be considerably less than that of the conventional advancing mine. How much less is conjectural, but that the saving would more than compensate for fixed charges arising from the greater first-cost of the retreating mine, I have no doubt. At the start, the situation would have to be faced that the cost of the coal would be still further increased something like this:

	Cents per ton
Interest on additional capital	2.32
Additional cost of haulage	4.50
Cost of maintaining and ventilating four miles of single entry, labor, timber and fuel, $40 per day	2.60
Total additional cost at start	9.42

Effect of Introducing New System.—Under present market conditions it would practically wipe out all profits for the average Illinois mine. This, together with the deferment of the time of getting the first returns, which ordinarily is from 1 to 1.5 years, to a total of 3.5 or 4 years, brings about a condition making it virtually impossible to enlist

new capital to open a mine in this way. The plan seems feasible only for the largest companies, and these would gradually change; that is, start mines on the retreating plan while operating their old properties on conventional lines. Evidently, large consolidations could best effect this purpose. To force an immediate change of old as well as new mines by State or national laws would be too drastic. To make the requirement for all new mines, if legally it can be done, would undoubtedly have the effect of restricting new developments. If the law were national in scope it would probably result in such curtailment of new output that very soon there would be a shortage of fuel and an increase in price until capital was again attracted. The effect would be even more severe in the mountainous states than in Illinois, inasmuch as the development of satisfactory methods to meet the physical disadvantages of steeply-pitching seams, or even level ones running under high mountains, will be difficult, and still more so where the seams are faulted.

LEGISLATION NEEDED.

Much, however, can be accomplished by voluntary means and by the making of such laws by the State as would require the filing of proposed plans of development for any new mine, and their approval by a board of examiners before mining is allowed to begin, plans leading to unsafe conditions and too wasteful in method not being permitted. This would amount to the giving of free engineering advice by specialists; but if it aided in conserving the mineral resources of the State and the country it would be worth more than the relatively small cost of maintaining such a bureau, either by the State, or by the State and the national government together.

EDUCATION NEEDED.

Much can be done by a campaign of education. This country has highly developed its coal mining machinery, and in this respect has been in the front rank, enabling it to produce cheap fuel with relatively high labor cost, but in the manner of laying out our mines underground and in directing the work at the face we have been practically stationary for years. When unusual conditions are encountered in a mine, that part of the mine is too often abandoned. We have fires and disasters sometimes due to lack of knowledge, care, or thoroughness on the part of the underground foremen, who are usually striving to make a record for tonnage.

Having so much easily mined coal, we have tended to avoid all adverse conditions, picking out the good spots. This has not developed our skill in meeting difficult conditions, so that we are undoubtedly far behind England and Europe generally in our work at the "face" of the mine. Our best mining foremen have been trained abroad in a practical way, even if their schooling has sometimes been acquired here.

We have much to learn; and now that the government has started on its campaign of education it is to be hoped that Illinois and other mining states will awake to the call for "the conservation of natural resources."

THE USE OF ILLINOIS COAL FOR DOMESTIC PURPOSES.

(BY J. M. SNODGRASS.)[1]

Under "domestic purposes," it is intended to include all heating, cooking, etc., by the burning of coal in stoves, ranges, and furnaces, or under house-heating boilers, in dwellings or other buildings. The amount of coal or other fuel so burned is large, and the question of its efficient combustion without undue smoke and dirt, and without troublesome fire conditions, is directly important to a large number of consumers and to the community as a whole. A satisfactory solution of the problems connected with burning Illinois coal for domestic purposes would mean a very considerable saving for the consumer and a much better market both within the State and throughout the territory naturally supplied with this coal.

Until recently, this subject has received little consideration as compared with the use of coal for power and for heating upon a large scale. The manufacturers of stoves, house-heating boilers, and like apparatus, have interested themselves more or less in this phase of the fuel question; but the results of their investigations are either not available, or are applicable to particular types of apparatus only.

The first settlers in the West, coming as a rule from more eastern states, brought with them the apparatus and methods of heating and cooking with which they were already familiar. These were largely adapted to the burning of anthracite coal and wood. Throughout Illinois, until comparatively recent years, the so-called "base-burner," a stove adapted for anthracite coal only, was commonly used for heating residences of the better class. In cooking stoves and ranges, wood or anthracite coal was, and still is, quite generally employed, especially where the expense of these fuels is not considered prohibitive. With the advent of hot-air furnaces and house-heating boilers, coming at first largely from the eastern market, the use of anthracite was still continued to a large extent. Owing to the constantly increasing price of anthracite and to the coal miners' strike of 1902, with the attendant scarcity of this kind of coal at that time, the use of soft coal for domestic purposes has now become much more common.

The fact that anthracite, and apparatus designed for burning it were first in the field, was in itself an advantage for that fuel over Illinois or other soft coals. Anthracite possesses a comparatively high heating value;

[1] Prepared under the direction of L. P. Breckenridge, Director of the State Engineering Experiment Station.

little of it need be lost in handling; it can be burned efficiently and but a small portion of it is ash or inert matter. Consequently, a smaller weight of anthracite than of average Illinois coal will have to be handled in the generation of a given amount of heat. Moreover, anthracite is easily handled, comparatively free from dust, and has an advantage over Illinois coal in the matter of cleanliness in the boiler room. It holds fire well. The fire is easily regulated, does not smoke or make soot to an objectionable extent, leaves little ash, and, ordinarily, the coal does not clinker badly.

The burning of Illinois coal is usually accompanied, to a greater or less extent (depending upon a number of conditions, such as furnace and boiler arrangements, kind, size, composition and preparation of the coal), by some or all of the following disadvantages: It is dirty, soiling clothing or other material with which it may come in contact. In handling it, more or less dust is raised. Fires are more difficult to regulate and, under many conditions, do not keep as well as an anthracite fire. Smoke, soot, and noxious gases are given off from the fire, and these are much more liable to escape from the furnace into the boiler room than is the case with anthracite coal. The heating value of the coal is lower, and the ash content is higher than in anthracite, and it is difficult to burn it with the same efficiency. These conditions necessitate a large supply for a given amount of heating to be done, more storage space and more handling of coal. The high ash implies a correspondingly large amount of ashes to be moved, and the tendency to clinker to a troublesome degree is more pronounced.

For the purposes of the present paper, coke can best be roughly classed with anthracite. When burned in stoves and heaters it possesses many of the properties and advantages of anthracite coal, and, to a large extent, is free from the objectionable features incident to the burning of soft coal. Like anthracite, however, it must, for use in Illinois and most other western states, be transported long distances, or the coal from which it is prepared must be so transported. Coke as a by-product from local gas plants is on a somewhat different footing from coke imported for fuel purposes only, and must be considered with this fact in view.

The great advantage of Illinois coal for the Illinois user and others within a reasonable distance of the field is its low price. First-class Illinois coal for domestic purposes can be purchased for one-half or less than one-half the price of anthracite. While the heating power of the anthracite is in general greater, the difference is not so great as to be in any sense commensurate with the difference in price. In Table I, which relates to some fuels tested under house-heating boilers at the University of Illinois, it will be noted that the B. t. u. (British thermal units) per pound of the anthracite listed is 12,690 as compared with a value of 12,278 for a comparatively high priced Illinois coal and a value of 10,473 for a somewhat cheaper Illinois coal. In one case the Illinois coal costs 46 per cent of the price of the anthracite coal and contains 96.7 per cent of its calorific capacity.

In the other case the Illinois coal costs only 34 per cent of the price of the anthracite and contains 82.5 per cent of its calorific capacity. This

TABLE I.—*Costs of Various Fuels.*

Fuel-tests with House-heating Boilers.

Kind of Fuel.	Cost per ton of 2,000 lb. at Urbana, Ill.	Cost in per cent based on anthracite coal as 100 per cent.	B. t. u. per lb as fired.	B. t. u. in per cent based on anthracite coal as 100 per cent.
		Per cent.		Per cent.
Anthracite coal	$8.25	100	12,690	100.0
Pocahontas coal	5.50	67	14,753	116.3
Coke (gas-plant by-product)	5.00	61	12,033	94.8
Coke (Solvay process)	6.00	73	12,488	98.4
Illinois coal (Christian county), nut	2.75	34	10,473	82.5
Illinois coal (Williamson county), washed nut	3.75	46	12,278	96.7

great discrepancy in price per heat-unit suggests the need of improvement in the methods of burning the cheaper fuel. Evidently, if all other conditions could be equalized or eliminated, the B. t. u. delivered by the fuel would be the direct measure of its value.

During the past two years the Engineering Experiment Station of the University of Illinois has made many tests of different fuels, chiefly Illinois coals. Those made upon fuels burned in the furnaces of house-heating boilers of standard types and of sizes suitable for average residences have embraced anthracite and Pocahontas coal, coke, a number of Illinois coals, and briquetted coal. These tests are still going on, and will be reported in the regular bulletins of the station, hence they will not be discussed in detail here. The relation of price to heating value, however, will be illustrated by a few figures taken from the data at hand.

Table III presents this relation, as based upon evaporative performance, for several of the best known kinds of fuel. The tests were made upon two house-heating boilers, here designated as D_1 and D_2; the former, made of four horizontal cast-iron sections (the base and grate section, the fire-pot, the intermediate section, and the dome), and the latter of vertical sections, connected by means of external drums or headers. Table II shows the dimensions.

II.—Dimensions of Test-Boilers D_1 and D_2.

	D_1 sq. ft.	D_2 sq. ft.
Rated capacity, radiating-surface	800	1,075
Area of grate-surface	4.28	6
Sectional area of chimney	1.07	1.07
Total heating-surface	43.7	75.87
	Cu. Ft.	Cu. Ft.
Total water and steam space	7.38	11.16

The height of the chimney above the grate in both cases is 39 feet.

Each boiler is supplied with special feed-water supply apparatus and a load-regulator, as well as with the gauges, thermometers and other auxiliary apparatus necessary for test purposes.

For the tests here considered, the evaporative performance of the boiler and fuel was deemed the best basis of comparison, and the tests were conducted with that as the main item sought. The problems of regulation, length of time of holding fire, smokelessness, ash, fire conditions, etc., was not overlooked but necessarily became secondary in importance; and observations and results relating to these questions are not reported here.

Fires were started according to the standard method of the A. S. M. E. code. The tests varied in duration, but were approximately either 8, 16, or 24 hours long. The fire was drawn when the boiler-pressure dropped below 4 or 5 pounds on the last firing, and did not again rise upon the opening of the damper and the closing of the check. The material drawn out at the close of the test was immediately put into a galvanized can with a close-fitting cover to prevent further combustion. Analysis of this partly-consumed or "residual" fuel furnished suitable corrections for the determination of fuel actually burned. The ash was kept separate from the residual fuel, being taken from the furnace and ash-pit before the fire was drawn. The fuel was sampled in the usual manner by taking a small portion from each firing. Analyses of the fuel, ash, and residual fuel were made at the chemical laboratories of the University of Illinois.

The feed-water, delivered to each boiler through measuring tanks, was the condensation from heating coils, and had a temperature near 180° F. Steam was exhausted to the atmosphere, after passing through a load-regulating device, arranged to give a load equivalent to about 65 per cent of the boiler-rating. A separator with suitable connections was used to determine the moisture in the steam; and the usual observations concerning temperatures, pressures, drafts, etc., were made.

Table III shows results, which are, for the most part averages of from three to six tests with each kind of fuel. Columns 1 and 2 give the kind and cost of each fuel. The samples were purchased mostly from local dealers, and the prices are given for quantities of from 1 to 5 tons only. Almost all these fuels can be purchased somewhat more cheaply in larger quantities; but domestic consumers are very likely to be retail purchasers. Column 3 gives the heating capacity per pound for each of the fuels listed, and column 4 the cost of 14,600 B. t. u. as purchased in each. (The number of 14,600 B. t. u., as the calorific capacity of a pound of pure carbon, is taken as a convenient unit for comparison. Column 5 shows that the boilers were operated at practically the same average capacity. The evaporation of 0.3 pounds of water per hour from and at 212° F. is taken as the equivalent of one square foot of radiation. Columns 6 an 7 give two of the principal operating conditions. Columns 8 and 9 give the cost of evaporating 1,000 pound of water from and at 212° F., and the fuel cost per hour

TALE III.—*Comparison of Fuel Costs—Data and Results—Fuel-Tests With House-Heating Boilers.*

1.	2.	3.	4.	5.		6.		7.		8.		9.		10.	
Kind of Fuel.	Cost of fuel per ton of 2,000 lb. Dollars.	B. t. u. per lb. of fuel as fired.	Cost of 14,600 B. t. u. Cents.	Per cent of builders' rating developed (based on 0.3 lb. water from and at 212° F. equiv. to 1 sq. ft. of radiation)		Fuel as fired per sq. ft. of grate-surface per hour.		Equivalent evaporation from and at 212° F. per hour per sq. ft. of heating-surface.		Fuel-cost of evaporating 1,000 lb. of water from and at 212° F.		Cost of fuel per 100 sq. ft of radiating-surface served per hr.		Efficiency of plant (boiler, furnace, and grate.)	
						Pounds.		Pounds.		Cents.		Cents.		Per Ct.	
				Boiler.		Boiler.		Boiler.		Boiler.		Boiler.		Boiler.	
				D_1.	D_2.	D_1.	D_2.	D_1.	D_2.	D_1.	D_2.	D_1.	D_2.	D_1.	D_2.
Anthracite coal	8.25	12,690	0.47	65.9	62.3	5.6	4.4	3.6	2.7	62.5	53.7	1.88	1.62	50.3	58.6
Pocahontas coal	5.50	14,753	0.27	63.6	64.0	5.2	4.1	3.5	2.7	40.2	32.6	1.20	0.98	44.9	55.4
Coke (gas-plant by product)	5.00	12,033	0.30	65.4	62.5	5.3	4.2	3.6	2.7	36.3	31.5	1.09	0.95	55.6	63.6
Coke (Solvay process)	6.00	12,488	0.35	64.4	60.8	4.6	4.0	3.5	2.6	38.1	37.1	1.15	1.11	61.1	62.9
Illinois coal (Christian county) nut	2.75	10,473	0.19	63.5	62.3	7.8	7.0	3.5	2.7	30.1	28.6	0.91	0.86	42.0	44.4
Illinois coal (Williamson county) washed nut	3.75	12,278	0.22	63.9	64.8	6.0	5.5	3.5	2.8	31.2	28.7	0.93	0.86	47.4	51.5

of serving 100 square feet of radiating surface. Column 10 gives the calculated efficiency of the boiler, furnace and grate, operated under the conditions of the tests.

It will be noted that the cost of evaporating, 1,000 pounds of water from and at 212° F. varies from 62.5 cents for anthracite to 28.6 cents for the cheapest of the Illinois coals tested. If evaporative performance alone be considered, this shows a saving of 54.2 per cent of the cost of the anthracite in producing the same effect. The similar differences between the same Illinois coal and the Pocahontas coal and the cokes, while not as great, are sufficient to warrant, other conditions being equal, the choice of Illinois coal on the ground of economy. Certainly a possible saving of from 10 to 50 per cent in the cost of a material which enters into practically every home, and the consumptions of which in Illinois alone is annually millions of tons, at several dollars per ton, is an object worthy of every possible effort.

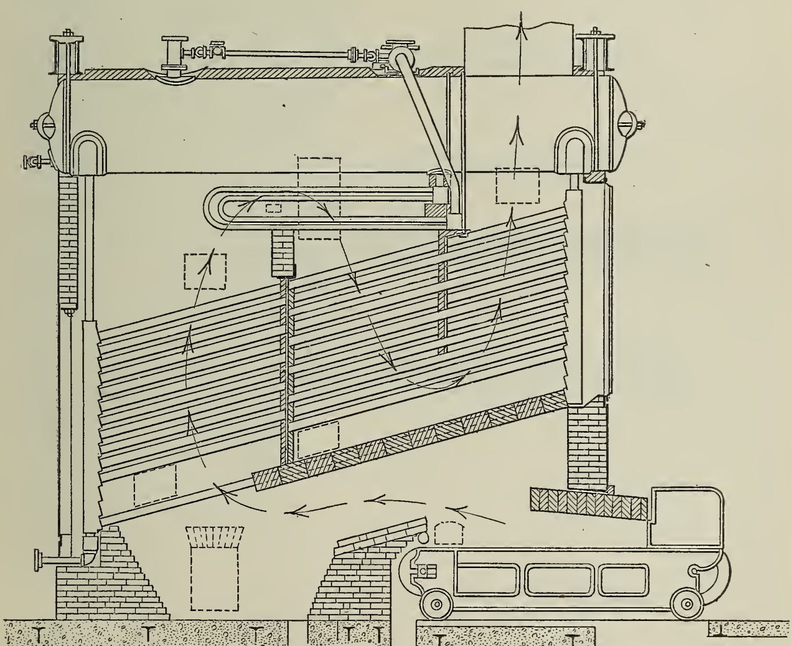
The endeavor of manufacturers to furnish stoves and furnaces suitable for Illinois coal, and that of coal dealers and others interested to disseminate information concerning this question, are evidence of a de-

mand for such apparatus and information, indicating that the general public appreciates the advantage to be gained by using this coal, as soon as some of its more pronounced disadvantages have been eliminated. Indeed, by the extent to which it is already using soft coal for domestic purposes, in spite of the attendant disadvantages, the public shows that it is determined to have the cheaper fuel. In this matter, the consumer is ahead of the manufacturer, the coal dealer, and the investigator.

THE SMOKELESS COMBUSTION OF BITUMINOUS COAL.

(BY A. BEMENT.)[1]

The present paper deals specially with Illinois coal; but the problem of smokeless combustion is the same for all bituminous coal, its difficulty being proportional to the amount of volatile matter in the fuel. It is to be assumed for the present purpose that coal from the Eastern Interior field, of which Illinois is a part, will make practically as much smoke as any other bituminous fuel, and, therefore, that a method or apparatus adequate for the smokeless combustion of this coal will be useful for any other.



LONGITUDINAL SECTION.

FIG. 4.—Improved Form of Boiler, Served by Smoke-Proof Furnace of the Kind Used in Electric Station Shown in Fig. 1.

Many persons still honestly doubt the possibility of burning bituminous coal without smoke. But experience has proved that it is entirely

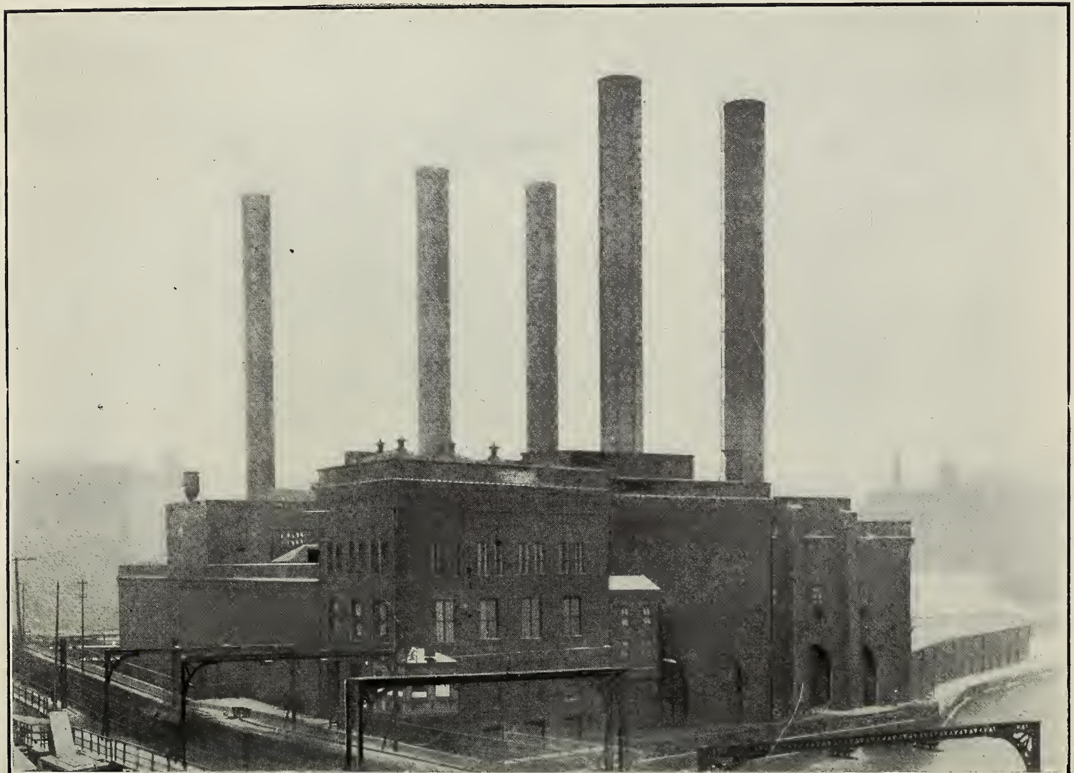
[1] Consulting Engineer, Chicago.

feasible in steam-making to employ apparatus which will be, except when fires are first lighted, entirely smokeless, so that a photograph taken of the chimney would show no smoke whatever—in fact, would give no indication whether the chimney was in service or not. Since, in many plants, fires are lighted only about once a month, this is practically a continuous smokeless operation. The achievement is due entirely to the inherent characteristics of the apparatus itself, and is not dependent in any sense upon the care or skill of the attendant. Chimneys have remained smokeless even when coal was being burned at the rate of one ton per minute.

Plate 3 is from a photograph of the Harrison street electric generating station of the Commonwealth Edison Company, Chicago, at which plant originated the smoke-preventing scheme here described. The boilers are of the Heine type, served by chain-grate stokers, and the application of the tile roof originated with Mr. W. L. Abbott, chief operating engineer of that company. The principle of the furnaces is illustrated by Fig. 4, which shows an improved form of water-tube boiler, devised by me, employing this tile furnace-roof, which is carried by the lower row of tubes in the boiler, thus forming an adequate combustion chamber.

The requirements for smokeless combustion, simply stated, are: (1) That the evolution of gas from the coal shall proceed uniformly; (2) that the gases distilled uniformly from the coal shall enter a fire-brick chamber, either (*a*) of sufficient length to allow their complete natural combustion, or (*b*) provided with such auxiliary mixing and baffling devices as will effect the artificial mixture and complete combustion of the gases before their exit from the chamber.

Uniform evolution of the volatile gases of the coal is the essential feature of the process, and it is for this reason that mechanical stokers, as a class, are more effective in preventing smoke than any apparatus accompanied with intermittent firing. A stoker, however, which, through abnormal working or incorrect manipulation, feeds irregularly, has the effect of a hand-fired furnace. Hence, forms of stokers depending upon gravity feed or having an inclined grate are objectionable, because sliding of the coal, or disturbance of the fuel bed by the attendant, may cause fresh coal to roll down in a large mass. Again, stokers which require that the fuel bed be disturbed in the removal of ash and clinkers cannot be depended upon for uniform feed of the coal, except under conditions of most favorable manipulation and suitable size and character of fuel. The chain-grate stoker, which operates with a horizontal fuel bed, receiving the fresh coal at one end and automatically and continuously discharging ashes at the other, insures a uniformity in feed of coal and condition of fuel bed not attained hitherto with any other machine of the kind. This form of stoker is shown in Fig. 4. In combination with a tile furnace roof, it satisfies requirements (1) and (2*a*) above stated. The adoption of this form of apparatus is extending rapidly. The University of Illinois has recently employed it in connection with an experimental boiler in its engineering laboratory.



Harrison Street Electric Station, Commonwealth Edison Co. Smoke-Proof Furnace in Full Operation.

Present practice largely tends, however, to some intermittent form of fuel supply, such as an irregularly working stoker, or hand firing, and attempts to secure a smokeless combustion are generally hampered by such conditions of firing. In such cases, requirement (2*b*), above stated, becomes imperative; and, for this purpose, resort is often had to various fire-brick walls, arches, etc., and other auxiliary mixing devices, such as steam-jets, with or without supplementary air supply. These schemes are never entirely successful unless there is a large and well-distributed auxiliary air supply available in the furnace chamber immediately after firing and while the volatilization of the coal is going on, because, after a fresh charge of coal is added, there is, for the first few moments, an evolution of volatile matter at a rate enormously larger than that of the whole remaining period between firings. Now, complete combustion requires not only a proper mixing, but a proportionately adequate supply of air. Consequently, with apparatus of any intermittent type, unless the rate of fuel supply approximates in uniformity that of a good stoker (which means, by hand, almost continuous firing), it is necessary not only to employ some powerful auxiliary mixing device, but also to furnish at times an extra air supply. The latter may be done by means of a steam-jet, automatically put in service as soon as the fresh coal is added, and discontinued after the expiration of a sufficient interval.

It is thus evident, that the stoker which produces results equal to that of the chain-grate is the only one which can be depended upon, under adverse conditions, to insure a positively smokeless result, independent of the skill, favorable disposition, or fidelity of the operator. Recently, a new form of underfeed stoker had been employed in the eastern states, which in considerable measure conforms to the chain-grate in its methods of disposal of the ash and in the manner of feeding the fuel. It has met with considerable favor where semi-bituminous coal, low in ash, is used. In feed of fuel and ash removal it resembles the well known "underfeed" and Roney types of stokers, having a fuel bed sloping to the rear, at which point are located dumping-grates for the removal of the ash—the fuel being introduced below the fire-bed at the front. Air supply by a forced draft entering the bed at the bottom insures that the volatile gases will become mixed with the air to a considerable extent before they leave the surface of the fire. With favorable fuel this form of apparatus has given satisfactory results under the Babcock & Wilcox type of boiler, without a tile roof, in those cases where the boiler was set high above the fire. But thus far there has been no reason to expect that with coal high in volatile matter and containing much ash it would be possible to secure favorable results without the aid of a tile roof furnace or its equivalent. The ash would necessarily have an important effect, because greater in quantity and sometimes readily fusible. Such large clinkers migh be formed that their removal would be difficult while the fire was in action. Conditions in Illinois, so far as ash content of the fuel is concerned, are quite serious, since the usual stoker fuel, under present methods of preparation, contains approximately 16 per cent of ash. It is with such fuel that the

result shown in Plate 3 has been secured. The general tendency at present is toward the abandonment of hand-fired apparatus and the correction of stoker operation so as to insure a uniformity in fuel feed.

One of the things which has operated seriously against the installation of many stoker applications is the general prevalence of the fallacy that it does not pay to employ stokers in small plants. It is, however, coming to be realized that only through stokers is it feasible to obtain the uniformity of feed required, not only for smokeless burning, but for good economy.

THE WEATHERING OF COAL.

(By W. F. Wheeler.)[1]

Experimental Data.

For the past two years the Engineering Experiment Station of the University of Illinois has carried on experiments to determine the nature and extent of the chemical changes taking place in stored coal.[2] Storage, under varying conditions, has been tried in order to learn how coal may be stored with the minimum loss by weathering. In these experiments different portions of the sample of coal were exposed to: (1) Regular weather conditions out-of-doors; (2) dry indoor storage at about 100° F. in boiler room; (3) the same, except that the coal was wet thoroughly every two or three days; (4) entire and continued submersion at about 70° F. Only the calorific value of the ash and water-free coal was made use of in determining the extent of the weathering. With this factor determined for the fresh coal as a basis of comparison, the submerged coal was found to remain practically unchanged for a period of nine months, while the other three portions of the same samples showed losses varying from 2 to 10 per cent, with no marked advantage in favor of either the outdoor or indoor storage, except that the coal with a large amount of pyrite was not broken up so much when kept dry as when wet often. The loss in calorific value practically ceased by the end of five months, although a slight loss occurred during the next four months.

A new series of experiments is now going on under more nearly normal storage conditions. Car-lot samples were obtained from three Illinois mines working different seams of coal. A car of 1.25 inch screenings and a car of 1.25 inch to 3 inch nut was shipped from each mine. One-half of each car was piled out-of-doors in an uncovered bin about 3.5 feet deep; the other half was piled about five feet deep in a covered bin, and a representative sample of each was submerged under water. Each of these cars of coal was sampled at the mine as the car was loaded, and again, about a week later, when it was unloaded. The purpose of sampling and analyzing the coal immediately after mining was to find out the composition of the coal before it had any chance to oxidize or lose its occluded gases. The second analysis, at the end of a week, was to serve as an indication of the rate of loss for that period. In Table I the analyses of the coal up to the end of the sixth month of storage are presented.

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[1] Chemist, State Geological Survey.

[2] Bulletin No. 17 of the Engineering Experiment Station of the University of Illinois, by Prof. S. W. Parr and N. D. Hamilton, presents the results of a preliminary series of tests on small samples of Illinois coal. A historical review of the literature on weathering and spontaneous combustion, and a summary of the opinions of various authorities are also given.

The losses represented in Table I range from 0.4 to 1.3 per cent at the end of one week after mining, from 0.2 to 2.2 per cent at the end of two months, and from 0.7 to 3.0 per cent at the end of six months. The average loss at the end of one week was 0.8 per cent; at the end of two months, 1.3 per cent, and at the end of six months, 2.0 per cent.

TABLE I.—*Loss in Calorific Value During Transit and Six Months' Storage.*

Screenings.

Coal from	Sampled.	Dry Coal.			B.t.u. of ash-, water- and sulphur-free coal.	Decrease.	
		Ash.	Sulphur.	B.t.u.		B.t.u.	Per cent.
Westville, Illinois	Same day as mined	17.88	2.35	11,937	14,684	......	......
	7 days after mining	13.84	2.58	12,462	14,627	57	0.39
	2 months after mining[1]	15.21	2.72	12,068	14,392	292	1.99
	2 months after mining[2]	15.26	2.51	12,124	14,453	231	1.57
	6 months after mining[1]	15.63	2.44	11,969	14,328	356	2.43
	6 months after mining[2]	14.51	2.25	12,081	14,247	437	2.98
	6 months after mining[3]	13.87	2.32	12,270	14,379	305	2.08
Springfield, Ill.	Same day as mined	17.13	4.92	11,752	14,478	......	......
	4 days after mining	17.04	4.47	11,684	14,351	127	0.88
	2 months after mining[1]	17.22	5.00	11,645	14,365	113	0.78
	2 months after mining[2]	18.33	4.70	11,414	14,254	224	1.55
	6 months after mining[1]	17.02	4.54	11,526	14,154	324	2.24
	6 months after mining[2]	17.30	4.67	11,466	14,136	342	2.36
	6 months after mining[3]	19.86	5.60	11,127	14,220	258	1.77
Herrin, Illinois.	Same day as mined	14.13	3.17	12,426	14,658	......	......
	6 days after mining	14.37	3.34	12,287	14,553	105	0.72
	2 months after mining[1]	15.66	2.67	12,133	14,545	113	0.77
	2 months after mining[2]	12.62	2.98	12,608	14,602	56	0.38
	6 months after mining[1]	13.76	2.84	12,342	14,476	182	1.24
	6 months after mining[2]	13.60	3.03	12,372	14,496	162	1.11
	6 months after mining[3]	14.38	3.54	12,262	14,528	130	0.89

3-INCH NUT COAL.

Coal from	Sampled.	Ash.	Sulphur.	B.t.u.	B.t.u. of ash-, water- and sulphur-free coal.	Decrease B.t.u.	Decrease Per cent.
Westville, Illinois	Same day as mined	10.55	4.25	12,991	14,768	......	......
	7 days after mining	13.98	2.65	12.412	14,586	182	1.23
	2 months after mining[1]	14.21	2.47	12,265	14,439	329	2.23
	2 months after mining[2]	13.08	2.13	12,475	14,523	245	1.66
	6 months after mining[1]	13.53	2.10	12,396	14,456	312	2.11
	6 months after mining[2]	11.76	2.14	12,571	14,365	403	2.73
	6 months after mining[3]	15.37	3.34	12,013	14,391	377	2.55
Springfield, Ill.	Same day as mined	17.87	5.75	11,741	14,655	......	......
	4 days after mining	16.63	5.10	11,800	14,461	194	1.32
	2 months after mining[1]	17.45	4.66	11,626	14,361	294	2.01
	2 months after mining[2]	16.83	5.02	11,796	14,452	203	1.39
	6 months after mining[1]	16.03	4.91	11,798	14,338	317	2.16
	6 months after mining[2]	16.30	4.52	11,682	14,218	437	2.98
	6 months after mining[3]	15.90	4.21	11,854	14,338	317	2.16
Herrin, Illinois	Same day as mined	13.98	3.75	12,499	14,751	......	......
	6 days after mining	14.90	3.02	12,341	14,682	69	0.47
	2 months after mining[1]	14.32	4.12	12,409	14,727	24	0.16
	2 months after mining[2]	14.08	3.84	12,378	14,634	117	0.79
	6 months after mining[1]	13.81	3.45	12,455	14,652	99	0.67
	6 months after mining[2]	13.06	3.60	12,469	14,551	200	1.36
	6 months after mining[3]	15.65	3.12	12,097	14,528	223	1.51

[1] Outdoor storage. [2] Covered bins. [3] Stored under water.

The loss taking place during the first week after mining represents two-thirds of the total for two months; and since very little coal can be used inside of a week after it is mined, not much importance attaches to the small additional losses of a two months' storage period. It may be of interest to add that the amount of loss by each of the three coals in question is in line with their reputation in the market—the Herrin coal breaks up least, Springfield next, and Westville most. A small sample taken from each car is being used to determine any change in weight which may accompany the change in calorific value, but, as yet, no results are available from these experiments. It is thought, however, that the weight of the dry coal will increase, due to the addition of oxygen to the coal. A sizing test of the coal is to be made in connection with this series of experiments to determine the amount of disintegration which takes place. It seems probable that this change in the size of the coal may have greater economic importance than the slight change in its composition. The loss in calorific value shown by the car-lots of coal in a period of two months is smaller than was expected, judging from the results of the preliminary series of experiments. The discrepancy is accounted for, most likely, by the greater exposure of the early samples, which consisted of but 25 pounds of coal each.

Two samples of old pillar-coal were also collected and compared by analysis with fresh coal from the same mine, to determine the extent of weathering in coal exposed for a long time underground. As the analyses in Table II show, the loss in calorific value is not very great, being in both instances under three per cent.

The Edwards coal presents an extreme case of weathering. The second sample was taken from near an outcrop that had been covered with soil and forest on a gentle slope, and had not been subject to erosion in recent years. The coal in this case had become so changed as to appear nearly like lignite, and the analysis shows a corresponding resemblance. The high moisture, nearly 30 per cent, is characteristic of the lignites, as is also a high percentage of oxygen, and a low calorific value.

Another point of importance in connection with the weathering of coals of the type found in Illinois and our western states is the occur-

TABLE II.—*Analyses of Pillar Coal and Fresh Coal.*

Coal From		Total moisture.	Analysis of Dry Coal.					Heat of Ash-, water-and sulphur-free coal.
			Ash.	Volatile matter.	Fixed Carbon.	Sulphur.	Heat.	
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	B.t.u.	B.t.u.
Belleville, Ill.	Pillar-coal exposed 22 yrs.	10.18	16.21	38.26	45.43	5.01	11,797	14,472
	Fresh face, same mine....	9.76	15.80	41.29	42.91	4.76	12,202	14,785
Equality, Ill.	Pillar-coal exposed 27 yrs.	4.76	13.84	36.56	49.60	3.84	12,514	14,754
	Fresh face, same mine....	4.47	10.85	47.82	51.33	3.72	13,235	15,188
Edwards, Ill.	Fresh face 300 ft. from outcrop....................	13.86	16.25	40.72	43.03	3.91	12,044	14,618
	Outcrop-sample..........	29.81	16.86	39.27	43.87	0.85	9,257	11,164

ence of a loss in calorific value even when samples are kept sealed up away from the air. The coal loses methane at first and absorbs oxygen from whatever air may be in contact with it. Each of these processes accounts for a part of the loss of heat units. If umpire samples are to be kept in connection with coal contracts calling for a specified calorific value, the heat unit basis, this fact must be kept in mind, since the loss in this way may become as much as 300 B. t. u. in a few months, as was shown in connection with my paper[1] presented at the Toronto meeting of the Institute, July, 1907, and again, with additional data, in the *Journal of the American Chemical Society*, for June, 1908.

SUMMARY.

The results to date on this series of tests confirm the conclusion set forth in the summary of Bulletin No. 17 by Prof. S. W. Parr and Mr. Hamilton, except that 4 per cent seems to be amply sufficient to cover the losses sustained by Illinois coals under regular storage conditions, the larger losses indicated in the former series being probably due to the small size of the samples exposed as against car-load lots in the present series. In these latter tests, the losses sustained by the submerged coal, though small in amount, are only slightly less than those indicated for the exposed coal.

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[1] Pure coal as a basis for the comparison of Bituminous Coals, Trans., American Ins Min. Eng., xxxviii., 621 to 632 (1908).

THE MODIFICATION OF COAL BY LOW-TEMPERATURE DISTILLATION.

(BY C. K. FRANCIS.)[1]

INTRODUCTION.

Since 1902 the laboratory of applied chemistry of the University of Illinois, under the direction of Prof. S. W. Parr, has been engaged in the investigation of bituminous coal, especially from Illinois, with a view to such a modification of it as will permit combustion under ordinary conditions without the production of smoke. Recent investigation, directed primarily to the development of fundamental facts and principles, has included a careful study of the chemical changes or reactions that may accompany the treatment of coal under varying temperatures and in different atmospheres.

Briefly outlined, the method is as follows: About 4 or 5 pounds of the coal was placed in a cylindrical retort, fitted with a three-quarter inch pipe at each end, one pipe serving as inlet tube for the gas used as an atmosphere, and the other as an outlet for the gases produced. These pipes also permitted the revolving of the retort during the operation. The atmospheres used in the experiments so far have been nitrogen, oxygen and steam. After the air was washed out of the retort by the gas to be experimented with, the retort was heated. The period of heating varied from two to three hours, the temperature from 200° to 425° C.

NITROGEN.

The results obtained in an atmosphere of nitrogen may be represented by those from a test in which the coal was heated for three hours, at an average temperature of 402° C. The analyses of the coal and the product, calculated for the same amount of ash, dry basis, are given in Table I.

TABLE I.—*Analyses of Coal and Product.*

	Original coal. Per cent.	Product. Per cent.
Ash	8.30	8.30
Volatile matter	36.23	15.26
Fixed carbon	55.47	51.98
Sulphur	2.24	1.32
B. t. u	13,244	9,819
B. t. u. (unit coal)	14,567	14,702

[1] Research Assistant in Applied Chemistry, University of Illinois.

The expression "unit coal"[1] is used here to represent the ash, water and sulphur free material. The formula for calculating the B. t. u. to the "unit coal" basis may be expressed as follows:

$$\frac{\text{B. t. u.} - (\text{Weight of S} \times 4{,}050)}{100 - (\text{Ash} + H_2O + 5/8\ S)} \times 100 = \text{B. t. u. per lb. unit coal.}$$

The gas evolved from the coal under this treatment had the following composition:

	Per Cent.
Carbon dioxide and hydrogen sulphide	17.33
Illuminants	9.54
Oxygen	0.0
Carbon monoxide	7.66
Methane	32.66
Hydrogen	2.37
Nitrogen	29.97
Volume of gas	50 liters.
Weight of coal	2,120 g.

STEAM.

The results after treatment in an atmosphere of steam for two hours at an average temperature of 381° C. were as follows:

	Original coal. Per cent.	Product. Per cent.
Ash	8.72	8.72
Volatile matter	39.07	25.78
Fixed carbon	54.19	55.79
Sulphur	2.57	2.14
B. t. u	13,304	11,959
B. t. u. (unit coal)	14,605	14,813

[1] Journal of the American Chemical Society, vol. xxviii., No. 6, p. 632 (May, 1906); and Trans., xxxviii., 621 (1908).

The gas evolved from the coal under this treatment had the following composition:

	Per Cent.
Carbon dioxide and hydrogen sulphide	32.40
Illuminants	7.30
Oxygen	0.80
Carbon monoxide	9.60
Methane	20.60
Hydrogen	0.00
Nitrogen	29.30
Volume of gas	37 liters.
Weight of coal	2,400 g

The carbon dioxide present in this gas, and, probably, also that produced when nitrogen was the atmosphere, may have been due to the residual oxygen in the retort. Indeed, the decrease in quantity of the carbon dioxide as the process was continued seems to indicate some such explanation.

Oxygen.

The results after treatment in an atmosphere of oxygen for 4.5 hours at an average temperature of 379° C. were as follows:

	Original coal. Per cent.	Product. Per cent.
Ash	8.52	8.52
Volatile matter	37.42	18.72
Fixed carbon	54.05	60.20
Sulphur	2.16	1.71
B. t. u	13,399	11,588
B. t. u. (unit coal)	14,768	14,793

The composition of the gas evolved from the coal under this treatment was as follows:

	Per Cent.
Carbon dioxide and hydrogen sulphide	12.73
Illuminants	3.53
Oxygen	9.27
Carbon monoxide	4.74
Methane	13.68
Hydrogen	0.00
Nitrogen	56.05
Volume of gas	50 liters.
Weight of coal	2,000 g.

In all cases the product has a lower heat value than the coal. This reduction is accounted for by the hydrocarbon values represented in the gaseous and oil products of distillation. Especial attention should be given to the heat values calculated to the unit coal basis. These values show a consistent increase throughout. A tentative explanation is, that the oxygen and nitrogen compounds of the volatile matter have been more largely driven off than the hydrocarbon compounds. If the loss in volatile matter, as shown, had been chiefly that of the marsh-gas (CH^4) series, a reduction in heat values for unit coal must result. If, however, the loss is made up of water of composition, there would be a relative increase in the heat value of the residual coal. The weight of water condensing in the flasks and separated from the oil, showed in each test an excess over the possible amount which could come from the free water present, amounting to 3 per cent in Test No. 4, 4.5 per cent in Test No. 6, and a little less than 3 per cent in Test No. 7. These figures must represent the percentage of decrease in the water of composition. A loss of 2 per cent in this constituent would raise the B. t. u. factor, referred to the unit coal basis, from 14,657 to 14,864. This seems to warrant the conclusion that a loss of water of composition occurs, which is an important point for further confirmation, since a fundamental purpose of this investigation is to develop, as nearly as may be, the conditions which govern the various decomposition processes.

Enough has already been developed to indicate that the product obtained by the treatment here outlined, or possibly a combination of two atmospheres, would have a special value for domestic use and for such industrial operations as require a smokeless fuel. While much of the volatile constituent remains, it has undergone a change which makes it not difficult to carry on combustion without the production of smoke. This fact is, perhaps, suggested by the rather close resemblance in composition to the so-called smokeless coals. Because of the very fragile character of this material, it would need probably to be briquetted.

The investigation of certain phenomena noticed in the preliminary experiments and in the work just described, suggested certain specific investigations. For example, carbon dioxide was present in the evolved gases when an inert gas, nitrogen or steam, was used as an atmosphere. In each case the amount was considerable, ranging from 12 to 27 per cent. In several of the tests an occasional rise of the temperature in the retort was noted, seemingly independent of the internal source of heat. The first investigation suggested was the determination of the temperature at which oxidation of coal begins, and the actual ignition point in different atmospheres. The apparatus devised for this purpose consisted of a purifying train, a heating chamber, and an apparatus for detecting carbon dioxide when evolved. In the flask employed as a heating chamber were placed two thermometers, one of which indicated the temperature of the gas, the other that of the coal under observation. Any difference in the readings of the two was due to reactions taking place within the coal. Oxidation was said to begin when carbon dioxide was detected at the outlet.

The results of these tests may be summarized as follows: Finely pulverized coals in contact with oxygen, either pure or diluted, as in the case of air, begin to oxidize at between 120° and 135° C. In some instances, however, this temperature of oxidation is higher, but in none of the tests did it exceed 155° C. The ignition temperature varies with the type of coal and, to a certain extent, also with the fineness of division. Powdered bituminous coals ignite in oxygen at a temperature of about 160°; buckwheat sizes ignite at from 260° to 300°; finely divided semi-bituminous coals at about 200°; and anthracite at about 300° C. Bituminous coals ignite in air at about 330° C.

The investigations of the phenomena occurring under the same conditions in atmospheres of steam and nitrogen are not completed. It has been demonstrated that an appreciable amount of carbon dioxide is formed in an atmosphere of pure steam, but at 315° C. there is an abrupt rise of temperature in the coal of over 50°, the limit of the thermometer preventing an exact determination. Since no increased appearance of carbon dioxide accompanied this rise in temperature, it must be attributed to the exothermic character of the decompositions occurring at that stage. Similar conditions were observed in a corresponding experiment, using nitrogen; but, since a small amount of oxygen remained in the nitrogen, giving as a result a moderate test for carbon dioxide at the exit tube, this matter of temperature differences in nitrogen must await further and more careful examination. Indeed, the general proposition here indicated, of a probable exothermic behavior, is of considerable importance, and calls for a carefully devised series of experiments, which are now in progress.

GENERATION OF POWER FROM ILLINOIS COAL.

ITS ELECTRICAL TRANSMISSION AND USE BY THE ILLINOIS TRACTION SYSTEM.

(BY H. C. HOAGLAND.)[1]

INTRODUCTION.

The Illinois Traction System, otherwise known as the McKinley System, is an organization furnishing interurban car service, electric light, power, steam heat and gas in central Illinois. Since it consumes 20,000 to 25,000 tons per month of Illinois coal, mined in the several fields of the State, and transmits the power long distances, a description of the equipment is of interest. This growing practice of power transmission promises large development in the immediate future.

PRINCIPAL POWER HOUSES.

THE PEORIA POWER HOUSE.

At the Peoria power house there are installed eight 400 H. P. Stirling boilers, which are fired automatically with Green chain grates, receiving their supply of coal from a bunker system overhead. The coal is elevated into the bunker system by a grab bucket and crane, which takes it direct from the cars or from storage bins of about 600 tons capacity located under the tracks.

In the turbine room are installed two 2,000 K. W. Curtis turbines, two 750 K. W. rotary convertors, and the auxiliary apparatus for the operation of such a plant. This power-house furnishes through the rotary convertors the 650 volts current for the operation of the Peoria Railway. The current is generated at 2,300 volts and stepped up through six 700 K. W. Westinghouse, water-cooled, oil-insulated, transformers to 430 volts, and through a 3-phase, General Electric, self-cooled, transformer for the motor exciter set to 2,300 volts.

To the bus bars in this station is connected a transmission line, which carries the current at 33,000 volts to two A. C. substations on the Peoria, Bloomington & Champaign Traction Company's line. One of these, located at Danvers, has a capacity of 400 K. W. Here the current is stepped down from 33,000 volts to 3,300 volts, or the voltage used on the A. C. trolley. At Morton, Ill., the substation has a capacity of 800

[1] Electrical and Mechanical Engineer of the Illinois Traction System.

K. W., and the current is also stepped down from 33,000 to 3,300 volts for the trolley. These two substations are run in multiple on a single phase trolley. They both receive their current from the same phase.

This transmission line also carries current to one substation on the Peoria, Lincoln & Springfield Ry., and two substations on the Springfield & Northeastern Ry., which have a capacity of 400 K. W. each. These substations are operated in multiple on the trolley, like those just described, except that they receive their current from a different phase from that furnished to the above company. This line also extends to the Riverton power-house, from which current can be supplied to the substations on the Peoria, Lincoln & Springfield and the Springfield & Northeastern when desired.

The transmission line also extends from Danvers east to Heyworth where a 300 K. W. rotary convertor substation is installed to step down current to the Chicago, Bloomington & Champaign Traction Company's line at this point. The line extends from here south to Clinton, Emery and Decatur. A portable substation of 300 K. W. capacity is installed at Clinton and at Emery. At Decatur the transmission line enters the substation through an oil switch and is connected to a common bus bar. From this the two 300 K. W. rotary convertors in the Decatur substation and a 300 K. W. motor generator set, used for day lighting during the summer, may receive their supply of current.

THE RIVERTON POWER-HOUSE.

At the Riverton power-house, which is located about six miles east of Springfield, there is installed eight 400 H. P. Babcock & Wilcox boilers, four of which are fired by Babcock & Wilcox stokers, and four by Green chain gates. These stokers receive their supply of coal from a storage bunker overhead, to which the coal is delivered by a conveyor system from a steel hopper in a track outside of the power-house. The ashes are taken by the same conveyor system to a bunker in the front end of the boiler-room and on the same level with the coal bunker. From this the ashes are fed through a spout to a car on the same track, used for unloading coal.

In the engine room at Riverton is installed one 28″ x 56″ cross compound condensing Hamilton Corliss engine, direct connected to a 1,000 K. W. 2,300 volt General Electric generator. There are also installed one 1,000 K. W. Curtiss turbine, and one 2,000 K. W. Curtiss turbine. These generators are all connected to a common bus bar through remote control oil switches, electrically operated.

From this power-house a transmission line extends east thirty-five miles to Decatur, and here connects to the common high-tension bus bar in the Decatur power-house. There is also a transmission line extending north from Riverton over the line of the Springfield & Northeastern Traction Company, and the Peoria, Lincoln & Springfield Traction Company, and power can be furnished from this power-house to the single phase A. C. substations, as above noted.

The third transmission line extends from Riverton to Stallings, a distance of about ninety miles. In this line 300 K. W. substations are located at Chatham, Virden, Anderson, Emerick, Gillespie, Staunton, Hamel, Edwardsville and Stallings. There is also a transmission line running across country from Gillespie to Litchfield, a distance of about ten miles, where another 300 K. W. substation is installed. From Litchfield, current is supplied both to the St. Louis & Northeastern Traction Company's lines running from Staunton to Hillsboro, and to a storage battery at Hillsboro.

The substations on the main line from Riverton south furnish power to the St. Louis & Springfield Traction Company's lines between Springfield and Staunton, and to the St. Louis & Staunton Traction Company's lines from Staunton to Granite City. From Granite City the cars run over the East St. Louis and Suburban tracks to their terminal near the Eads bridge. At Granite City the company is building a bridge across the Mississippi River to carry its cars directly into the city of St. Louis. This will be completed in about two years.

Going back to Decatur, a transmission line runs east from Decatur over the line of the St. Louis, Decatur & Champaign Traction Company to Champaign, a distance of fifty miles, and supplies current to 300 K. W. substations located at Oakley, Bement and White Heath. This line terminates in the power-house at Champaign, where the current is stepped down from 33,000 volts to 15,000 volts. At Champaign there is a 500 K. W. double-ended generator, direct connected to a Russell engine, which furnishes three-phase current through step-up transformers to a transmission line running to Danville. There is also a 500 K. W. Bullock direct current generator, direct connected to an Allis-Chalmers engine, which supplies the city lines in Champaign and the interurban lines running out of Champaign to Decatur and to Danville. There is, in addition, a 540 K. W. General Electric generator, direct connected to a Fulton Corliss engine.

From this power-house a 15,000 volt transmission line runs along the tracks of the Danville, Urbana & Champaign Ry. Co. to Danville, a distance of thirty-five miles, furnishing power to 300 K. W. rotary convertors located at St. Joseph and Fithian. The line terminates in the Danville power-house and is connected to a bus bar through solenoid operated oil switches. A transmission line running south from the Danville power-house to Georgetown furnishes current to a 300 K. W. rotary at the latter place, and also to the shops of the Danville Car Company. The Georgetown substation operates the line to Georgetown and Ridgefarm, a distance of eighteen miles. The Catlin line, extending a distance of five miles, is also supplied from the Danville power-house.

In the new addition to the Danville power-house is installed a pair of 36″ x 60″ Hamilton-Corliss twin engines, direct connected to a 2,000 K. W. 6,600 volt General Electric generator. This generator works on the transmission line between Danville and Georgetown, and also between Danville, Champaign and Decatur. There are installed in the boiler-room ten 400 H. P. Stirling boilers and two 500 H. P. Stirling boilers, making a rated capacity of 5,000 H. P.

In the old engine room at Danville are installed one 300 K. W. 250 volts three wire Western Electric generator, direct connected to a Tandon compound Russell engine; one 26″ x 52″ cross compound Hamilton engine to which is direct connected an 800 K. W. 2,300 volts General Electric generator; one 28″ x 48″ Hamilton-Corliss engine, to which is direct connected a 600 volt General Electric, direct current generator for railway use. There are also six engines from 150 to 500 H. P. capacity, to which are belted generators from 100 K. W. to 300 K. W. capacity each, for day service. There are also in this station two 300 K. W. rotary convertor equipments that receive their initial power from the transmission line.

Minor Power Houses and Utilities.

At Edwardsville is installed a 500 K. W. generator, direct connected to a cross compound engine, which works in multiple with the generators in the Riverton power-house, supplying current to the transmission lines at 33,000 volts. At Bloomington the company owns a power-house in which are installed eight 400 H. P. Stirling boilers and two 300 H. P. Heine boilers. This plant furnishes electric lighting, steam heating, hot water heating and street railway service. At Danville, the company furnishes electric lighting, steam heating, gas and street railway service. At Urbana a power-house of 700 H. P. capacity supplies electric lighting and steam heat. At Champaign, electric lighting, gas, steam heating and street railway service are maintained. At Decatur, the company provides electric lighting, steam heating, gas and street railway service. The Decatur power-house also has a capacity of 200 H. P. of Stirling boilers. At Peoria, the company furnishes street railway service only, at Edwardsville, electric lighting, and at Granite City, electric lighting and street railway service. At Jacksonville, another power-house is operated from which is furnished electric lighting and street railway service. Gas is provided from these properties also.

The interurban system comprises about 450 miles of interurban railway as well as the several city lines mentioned. Several extensions to the interurban system are proposed. The company not only handles a passenger business, but operates sleeping cars and chair cars between Springfield and East St. Louis and points north, and from Danville to points south. It owns and operates several refrigerator, express and freight cars, and several hundred coal cars. The coal for the several power houses on the system is largely handled by electric locomotives on the company's own tracks, as well as a large quantity of coal for commercial purposes.

All of the cars signaled over the company's private telephone lines, by dispatchers located at Staunton, Decatur, Mackinaw and Danville. Duplicate telephone lines for the commercial use of the company in handling its enormous business are also being installed. The cars are protected by Blake signals operated by the dispatchers, and the Peoria, Bloomington and Champaign Traction Co. has recently been equipped with McClintock automatic block signals.

The Purchasing Department of the Company is located at Decatur, where the supplies are stored for use along the lines. The general repair shops are also at Decatur. These are equipped with electrically driven wheel lathes, boring mills, planer lathes, pipe cutting machines, etc. Car barns are provided at Danville, Champaign, Decatur, Bloomington, Peoria, Lincoln, Staunton and Jacksonville, where inspections and minor repairs are made.

The office of the electrical, mechanical and operating engineers is at Decatur. The general accounting offices are in Champaign and the general manager has offices at Danville and Springfield.

SUMMARY AND CONCLUSIONS.

(By H. Foster Bain.)

Coal Reserves.

In the section of this paper written by Mr. DeWolf, the amount of available coal in Illinois is shown to be so large as to warrant a feeling of security for the future. It is not likely that any scarcity will be felt in this field for several generations to come. While, as indicated by Mr. Lindgren in the analyses submitted, the grade of the coal is not the highest, this is more than offset by the abundance.

Mining Costs and Conditions.

It has been shown by Mr. Rice that there are large losses in the present methods of mining employed in this field, but that the remedy for these may be easily found so far as technical performance is concerned. The difficulties lie in the financial and industrial situation, and until the average price of coal increases or the rate of interest falls, only minor improvements are to be expected. Certain changes which are possible even under present conditions are pointed out.

Present Methods of Utilization.

Illinois coal is now largely used for domestic heating, power generation and locomotive consumption. For the first purpose the most important limiting factor is its supposed lower heating value as compared with competing eastern coals. This, Mr. Snodgrass shows, is, price considered, fictitious; and it is suggested that with the development of proper apparatus such actual difference as does occur may be decreased, if not entirely wiped out. It is therefore to be expected that the domestic market for Illinois coal will in the future not only expand with the population but at an increasing rate, both by actually displacing competing coals and by the capture of a larger share of the new market. While this phase of the subject has not been discussed here, it may be pointed out that the increased use of washeries in preparing coal for the market will aid this movement by furnishing to domestic users a cleaner and lower ash coal.

For power generation in stationary plants a smokeless coal is becoming increasingly important, and Mr. Bement shows that it is entirely possible to burn the worst of the Illinois coals with extremely satisfactory re-

sults as regards smoke. This removes one of the large handicaps under which Middle Western coal has heretofore labored. One of the developments of the future will undoubtedly be as suggested by Mr. Hoagland toward larger central power plants and the distribution of energy, probably as electricity.

One other development which is likely to influence the future market of Illinois coal is the larger use of the gas engine. It is to be regretted that specific data on this point could not be included in this symposium. The reports of theFuel Testing Plant of the U. S. Geological Survey[1] show that Illinois coals are excellently adapted to such use; and as a matter of fact they are now being so used at one or two points. The large installation of gas engines in the steel plant at Gary is one of the significant signs of the times. It cannot be doubted that there will be an increasing use of gas engines; and since the gas producer tends to some extent to wipe out the margin between high grade and low grade coals, in the long run this change will be to the advantage of the coal fields of the interior.

It is somewhat difficult to get at the amount of coal used for locomotive purposes. In the fiscal year ending June 30, 1907, Illinins produced 46,700,608 tons of coal. For the corresponding term the locomotive consumption for the State of Illinois, as given by the State Railway and Warehouse Commission, was as follows:

Locomotive Consumption of Coal in Illinois.

	Passenger service.	Freight service.	All service, including switchind and construction.
Miles run	39,183,431	50,167,137	113,584,275
Tons used	2,140,199	4,590,916	9,220,119
Pounds per mile	109.34	183	138.01

These figures are representative only. While most of the coal came from the Illinois mines, a minor portion was from Indiana and eastern states. On the other hand, a very large tonnage of Illinois coal goes to supply locomotives running in other states. At present it is impossible to give figures covering this tonnage, though they are being collected.

The performance figures given, representing as they do a very large engine mileage, may safely be assumed as averages in computing future consumption with increased railway activity. The average number of engine miles per ton, including switching and all kinds of service, amounted to 12.85. Corresponding figures for September, 1907, for various roads in the Middle West using Illinois coal were, 13.38, 12.2, 14.7, 17.18, 13.69. The figure is probably a little low rather than the reverse. It will be noticed that approximately 20 per cent of the coal output was used for locomotive purposes in the State. In 1905, the corresponding figure was 25 per cent. About half of this is used in

[1] Bulletins Nos. 261 (1905), 290 (1906), 332 (1908), and Profesional Paper No. 48 U. S. Geological Survey, pp. 981 to 1325 (1906).

the freight service, and it may be roughly computed that 1,000,000 tons are burned in hauling to place of consumption the remaining 50,000,000 tons of output.

Possible Future Improvements.

One great hindrance to a wide use of Illinois coals is the poor shipping quality. They do not stand rehandling, and in storage they are subject to deterioration and spontaneous combustion. For this reason they do not enter distant markets, except by all-rail routes and at the season of maximum demand. This not only limits the total output of the mines, but adds to the normal cost per ton the expense of idle plants and men for some 30 or 40 per cent of the time, it being necessary in order to meet maximum demands to have a capacity in large excess of the average demand. For these reasons studies of the weathering and deterioration of our coals are of peculiar interest. Different phases of this subject are brought out by Messrs. Barker and Wheeler, while Mr. Francis gives some of the fundamental facts regarding the decomposition of coal and its oxidation at low temperature. The weathering studies now going on are too incomplete to permit the drawing of general conclusions. It is shown that submerged coal does not deteriorate, except by loss of the occluded gas; and, since it is also protected from spontaneous combustion, such a storage plant, where commercially feasible, may be best. It is hoped, however, that a more satisfactory solution of the difficulty may be found. In this connection Mr. Francis' work on what might be called "anthracitizing coal" offers some suggestions though not as yet any conclusions commercially available.

Markets for Illinois Coals.

The coal production and consumption for 1906, the last year for which figures are available, may be estimated as shown in the tabulated statement on the following page.

It will be noted that the railways are the largest users of Illinois coals. Next to them stand the cities of St. Louis and Chicago. On the face of the figures St. Louis is much the larger user. These figures are slightly deceptive, since it is impossible to separate the eastern coal, aside from anthracite, from the Illinois coal handled by the roads running into St. Louis. In 1906, in Chicago, 2,961,926 tons of Indiana coal were also used. In the year studied 4,265,528 tons were used at or near the mines and did not enter the general competitive market. It is, apparently, safe to conclude that at least half the coal mined is used within the State. If the quantity of coal shipped from the mines to local dealers were known it is probable that this portion would be found to be larger. In other words, Illinois derives not only the benefit of mining but the profit from burning half its output.

Production and Consumption of Illinois Coal for 1906.

	Tons.	Tons.
Total production	41,480,104	
Consumption:		
Used by railways within the State (estimated by percentage)		9,333,000
Shipped to Chicago		[1] 4,968,102
Shipped to St. Louis		[2] 6,600,216
Used at mines		[3] 1,374,308
Sold to local trade and to employees		[3] 2,891,220
Shipped to railways outside, and to local consumers within and outside the State		[4] 16,313,158
Total		41,480,104

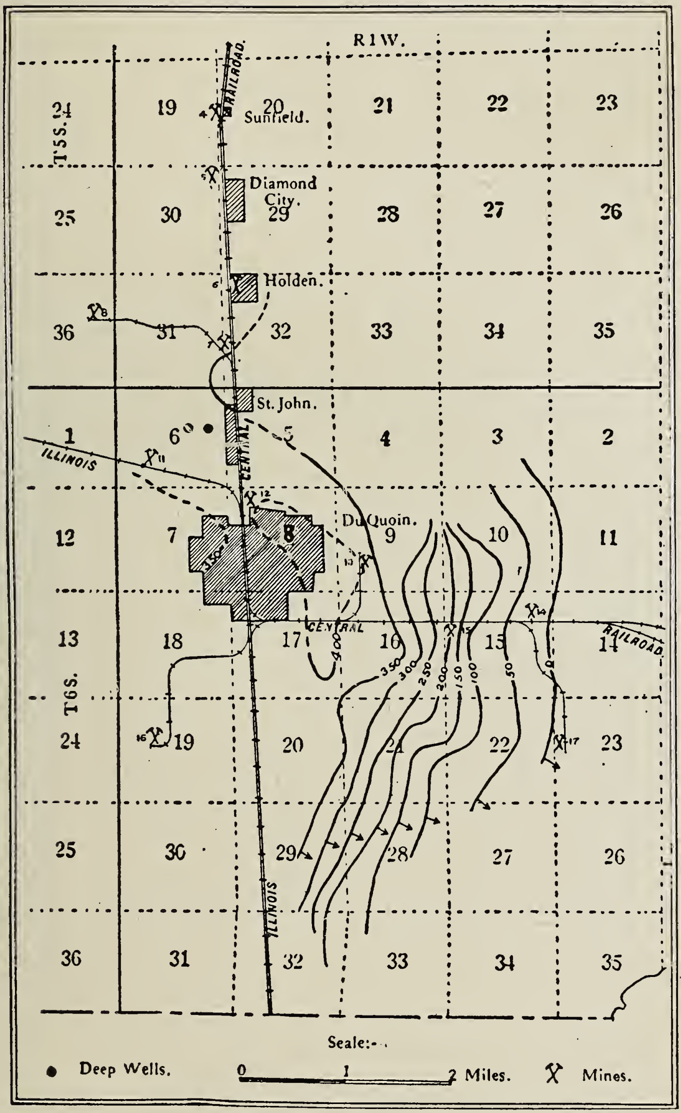
Of the local markets, that of Chicago is the most important and can be studied in most detail. The receipts and shipments at this point in 1906 are given below.

Coal Receipts and Shipments at Chicago in 1906.

(Chicago Bureau of Coal Statistics.)

Receipts.	Tons	Tons.
Anthracite:		
By lake	781,751	
By rail	744,531	
Stock, Jan. 1st	403,976	
Total		1,930,258
Pennsylvania bituminous	925,237	
Ohio coal	856,833	
West Virginia	914,420	
Coke	342,919	
Total eastern bituminous and coke		3,039,409
Illinois coal:		
Northern field	1,100,915	
Southern field	3,153,956	
Central field	270,456	
Eastern field	442,775	
Total Illinois		4,968,102

[1] Chicago Bureau of Coal Statistics.
[2] St. Louis Coal Traffic Bureau. These figures include eastern coal received by railway.
[3] According to U. S. Geological Survey.
[4] By difference, assuming no stock carried over.



Geological Structure at Duquoin, showing the easterly dip by 50 foot contours which indicate the elevation above sea level of Coal No. 6.

Coal Receipts and Shipments at Chicago in 1906—Concluded.

Receipts.	Tons.	Tons.
Indiana coal:		
Brazil block	165,075	
Miscellaneous bituminous	2,796,851	
Total Indiana		2,961,926
Total Western coal		7,930,028
Total coal and coke		12,495,719
Shipments:		
Anthracite		542,554
Bituminous		2,772,204
Coke		258,316
Total shipments		3,573,164

Corresponding figures for a series of years show that in this important market the use of Illinois and Indiana coal has been increasing at the expense of eastern coals. That at the present ratio of prices they may well be expected to continue to do so, is shown by the following tabulation, in which the Chicago price is an average of the Black Diamond weekly quotations for January and February of 1907 (a period of normal demand), and the fuel value is based on large commercial deliveries for one year with semi-monthly sampling and analysis by the Fuel Engineering Co. For convenience in further discussion the freight rate to Chicago is added. While it is probable that only a portion of the coal marketed in Chicago actually sold at the prices indicated, much being delivered under long-time contracts, the prices none the less fix the ratio of competition, since they are the quoted prices for the excess coal reaching out for a market.

Competing Coals in Chicago Markets.

Coal.	Chicago Price.	Freight-Rate.	Thousand B.t.u. for a cent.
Franklin county (Ill.) screenings	$1 59	$1 00	140
Clinton county (Ind.) mine-run	1.77	0 70	124
Springfield (Ill.) mine-run	1 75	0 75	122
Pittsburg (No. 8 Ohio)	2 91	1 60	90
Carterville, Ill., washed No. 2	2 90	1 00	80
Pocahontas	3 46	2 05	80
Hocking (Ohio)	3 54	1 65	70
Indiana block	3 20	0 80	68

The average for the five western coals gives 107,000 B.t.u. for a cent, and for three eastern coals, 80,000 B.t.u. It will be noted that consumers using eastern coals and Indiana block pay on an average 64 per cent greater coal bills as a penalty for not adapting their furnaces

to the burning of the local coals. At these prices the producer of Carterville washed coal is able to spend 49 cents a ton more on his product than the miner of Pocahontas coal, and yet deliver the same number of heat-units for a dollar to his Chicago customers. It is evident that Pocahontas, the best of the eastern coals, can never be delivered in Chicago at existing freight rates in competition with Illinois coals when consumers adapt their furnaces to economical and smokeless burning of the latter.

This leads to an inquiry regarding existing and future freight rates. As is well known, coal freight rates generally are very low and the rate per mile decreases rapidly with distance. The following are a few coal freight rates per ton per mile.

Illinois Coal Freight Rates.

	Rate. Cents.	Approximate rate per ton-mile. Cents.
Northern Illinois to Chicago	50	0.50
Central Illinois to Chicago	75	0.37
Southern Illinois to Chicago	100	0.33
Chicago and Northern Illinois to St. Paul and Minneapolis	140	0.28
Central Illinois to St. Paul and Minneapolis	180	0.28
Southern Illinois to St. Paul and Minneapolis	210	0.29
Peoria to Omaha	226	0.54
Central Illinois to Omaha	202	0.28
Southern Illinois to Omaha	237	0.25
Pittsburg district to Chicago	165	0.33
Pocahontas to Chicago	205	0.30

While these figures show some difference between local and long distance shipments it must be remembered that a minimum initial charge is to be taken into account, and if they be plotted it will be seen that there is small likelihood of the local rates decreasing much relative to the distant rates unless the whole system be changed. It is to be expected, therefore, that, so far as freight rates are concerned, competition will remain substantially as it is at present.

The decrease in the rate per ton per mile with distance gives a marked advantage to higher grade coals in the distant market. If, for example, two coals differ in original price 25 cents, selling for $1.00 and $1.25 respectfully, the difference is equivalent to 20 per cent of the price of the better coal. If now an initial freight rate of 50 cents be paid, the difference amounts to only 14 per cent, and with each increase in freight the original difference in cost decreases until when a $2.00 rate is paid it amounts to only 7.6 per cent. This is the explanation of the fact that screenings are used near the mine, and only washed coal and lump are exported to a distance. Indeed, lump coal has a fictitious value within the mining regions and finds a local market for special purposes only.

Practically no Illinois coal moves eastward. This is due not only to competition based on the quality of the eastern coals, but to the present organization of freight traffic, which makes it difficult to get cars. Such coal as goes east from this coal field is supplied by Indiana. To the west, Illinois coal dominates the markets of Missouri and Iowa almost to the eastern margin of their own coal fields, and has a scattering trade beyond. To the southwest, coal is furnished to the railways to a point about half way between St. Louis and Kansas City, and to a few supply stations beyond. Directly south, there is very little coal movement except to supply certain connecting railways. The larger markets are dominated by eastern coal shipped by river, a traffic practically closed to Illinois operators for the present, owing to lack of terminals within the State, and the poor stocking-qualities of the coal. To all intents and purposes the only Illinois coal delivered to the rivers is that used by the local steamboats.

To the north and west, the coal goes in large quantities into southwestern Wisconsin, northern Iowa, southern Minnesota, and eastern South Dakota. On the one hand it must meet the competition of the nearer Iowa fields, and on the other, of the lake-shipped eastern coal. The size of this lake trade may be illustrated by the figures for 1907.

Lake Shipments of Coal in 1907.

	Tons.
Western Pennsylvania coal	8,306,143
Ohio coal	3,703,322
West Virginia coal	3,343,752
Total	15,353,217

The lake coal dominates the market as far south as Milwaukee, and it is only of recent years that Illinois coal has begun to go in any quantity as far northwest as St. Paul and Minneapolis. In the territory between these points there is much debatable ground, and if methods of storage can be devised so that the coal may be shipped in the summer, large increases in trade may be looked for. The same is true of western Iowa and eastern Nebraska, where at present there is only a moderate trade. If, in addition to finding a solution of the storage problem, water transportation be made available, Illinois coal may become a dominant factor in the Northwest. It must be admitted, however, that this is far from being accomplished, and for the present, in extending the markets, reliance must be placed mainly on a campaign of education in the proper burning of high volatile coals.

The purchase of coal on specifications is also to be commended. This not only leads to closer studies of coal bills and conditions of burning, but, by means of the inspection system, improves the mining and cleaning of the coal. While doubtless criticism can be fairly made of particular specifications, it is believed that the system itself will, in the long run, commend itself both to buyers and sellers.

COAL DEPOSITS AND POSSIBLE OIL FIELD NEAR DUQUOIN ILLINOIS.

(By Jon Udden.)

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INTRODUCTION.

Perry county is situated in the southwestern part of the State, and has an area of 440 square miles. The adjoining county on the north is Washington, on the west Randolph, on the south Jackson, and on the east Franklin and Jefferson. The region under consideration is situated in the southeastern part of the county, where Duquoin is the most important coal center. Very little has been written on the local geology, the most important contribution being that of A. H. Worthen in his Geology of Perry County.[1] J. M. Nickles published a geological section extending from St. Louis to Shawneetown,[2] which crosses the extreme northeast corner of the county. Later, Prof. Frank Leverett contributed to our knowledge of the glacial geology as well as to that of the water resources, giving complete data of the deep salt well put down by the Illinois Central Coal and Coke Company.[3] The reports of the State Bureau of Labor Statistics giving very interesting data on mining and labor conditions, equipment and complete statistical data on coal production. Many other publications touching in a general way on the field could be mentioned. Ashley's[4] and DeWolf's[5] contributions being perhaps the most important ones of recent dates.

THE ROCKS OR STRATIGRAPHY.

The country rock belongs to the Pennsylvanian series, and in places where the mantle covering has been removed by erosion, outcrops of shale, sandstone and limestone may be noted. These are, however, very limited on account of the general presence of the drift cover. The surficial deposits are variable in thickness and usually show near the base the presence of buried portions of trees. Whether this buried vegetation occurs between two drift sheets cannot definitely be determined on account of the meagerness of detail in the records.

From deep explorations it is possible to ascertain the relation and thickness of some of the underlying formations. In this neighborhood some fifty tests, from 45 to 500 feet in depth, have been made for coal, besides two deep holes, one about 1,000 feet and the other 3,600 feet.

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1 Geol. Surv. of Ill., vol. III., pp. 84-103, 1868.
2 Rep. Ill. Board World's Fair Commissioners. P. 169, 1893.
3 Ill. Glacial Lobe, U. S. Geo. Surv. Mon. 38, pp. 771-773.
4 U. S. Geol. Surv. 18th Ann. Rept., pt. 3, pp. 202-283. 1902.
5 Trans. Amer. Inst. Min. Eng., pp. 1100-1169. October, 1908.

The record of the deepest boring made by the Illinois Central Coal and Coke Company at St. Johns, kindly furnished by Mr. John Forrester has been interpreted by the writer and is as follows:

LOG OF DEEP BORING AT ST. JOHNS, ILLINOIS.

	Thickness. Feet.	Depth. Feet.
Recent and Pleistocene—		
Glacial drift	42	0– 42
Pennsylvanian—		
Lime rock	3	42– 45
Sandy shale	16	45– 61
Shale and coal	10	61– 71
Sandy shale	25	71– 96
Clay shale	30	96– 126
Sandy shale	80	126– 206
Sand rock	15	206– 221
Sandy shale	23	221– 244
Fire clay and shale	12	244– 256
Shale with partings	55	256– 311
Sand rock, fresh water	178	311– 489
Mississippian—Chester, Cypress and Ste. Genevieve—		
Lime rock	31	489– 520
Sand rock, 15 per cent salt	15	520– 535
Sandy shale	28	535– 563
Sand rock	15	563– 578
Sandy shale	32	578– 610
Lime rock	8	610– 618
Sand rock	25	618– 643
Shale	13	643– 656
Sand rock	10	656– 666
Lime rock	3	666– 669
Sand rock	10	669– 679
Clay shale	30	679– 709
Sandy shale	35	709– 744
Mixed shale	35	744– 779
Lime rock	16	779– 795
Shale	20	795– 815
Lime rock	25	815– 840
Clay shale	15	840– 855
Lime rock	5	855– 860
Sandy shale	15	860– 875
Clay shale	40	875– 915
Sandy shale	67	915– 982
Lime rock	20	982–1,002
Sand rock	20	1,002–1,022
Lime rock	10	1,022–1,032
Sandy shale	22	1,032–1,054
Sand rock	13	1,054–1,067
Sandy shale	20	1,067–1,087
Lime rock	20	1,087–1,107
Red marl	4	1,107–1,111
Sand rock	39	1,111–1,150
Sandy shale	40	1,150–1,190
Sand rock	90	1,190–1,280
Soft shale	10	1,280–1,290
Sand rock	10	1,290–1,300
Blue lime	5	1,300–1,305
Sand rock	5	1,305–1,310
Shale	10	1,310–1,320
Sand rock	10	1,320–1,330
Shale	14	1,330–1,344
Red marl	4	1,344–1,348
Shale	4	1,348–1,352
Lime rock	16	1,352–1,368
Shale	7	1,368–1,375
Sand rock	14	1,375–1,389
Lime rock	10	1,389–1,399
Sand rock	15	1,399–1,414
Lime rock	6	1,414–1,420
Shale with partings	20	1,420–1,440
Lime rock	35	1,440–1,475
Shale	23	1,475–1,498

Log of Deep Boring at St. Johns, Illinois—Concluded.

	Thickness. Feet.	Depth. Feet.
Mississippi—Chester, Cypress and Ste. Genevieve—*Concluded.*		
Sand rock	20	1,498–1,518
Shale, mixed	19	1,518–1,537
Lime rock	4	1,537–1,541
Sandy shale	8	1,541–1,549
Lime rock	40	1,549–1,589
Shale	15	1,589–1,604
St. Louis, Salem and Warsaw—		
Lime rock, 38 per cent salt	92	1,604–1,696
Shale	3	1,696–1,699
Lime rock, 38 per cent salt	250	1,699–1,949
Fire clay or shale	20	1,949–1,969
Lime rock with partings	57	1,969–2,026
Shale	10	2,026–2,036
Osage and Kinderhook—		
Lime rock with partings	102	2,036–2,148
Sandy lime rock	160	2,148–2,208
Light gray lime rock	63	2,208–2,271
Spar, calcite crystals	4	2,271–2,275
Devonian—		
Light gray lime rock, hard	498	2,275–2,773
Light gray lime rock, soft	227	2,773–3,000
Silurian—Cincinnatian and Galena-Trenton—		
Mainly limestone to 3,600 feet	600	3,000–3,600

Another boring, 1,000 feet deep, near the above, was put down by the same company.

The deeper parts of these two records present a rather puzzling geologic section. As shown in them and in some fifty other records, the Pennsylvanian series has a maximum thickness of about 500 feet, consisting principally of shales, sandstones, some limestone and coal. The Mississippian series is represented by about 1,700 feet of sediments.

From 3,063 to about 3,150 there is a shale which contains some thin ledges of limestone. At 3,100 feet this shale is black and contains bituminous material. It lies about the same distance below the red marls of the Chester that a similar shale does in a well at Mascoutah—about 1,700 feet. In the Mascoutah well this shale lies 500 feet above the St. Peter's sandstone, which formation does not appear to have been reached by the St. Johns well, and which probably lies here at a depth of 3,800 feet below the surface.

Coals.

As has already been stated, the principal sediments consist of shales, sandstone and limestones. Associated with these are coal beds of variable thickness, but the only seam mined in this area is the Blue Band or No. 6. Besides this, two other coals are of interest, one occurring above the No. 6, coal, and one below it, possibly No. 5. The topmost coal occurs from 45 to 120 feet above the No. 6 seam, having a thickness varying from a few inches to a couple of feet. It is not workable on account of being so thin and irregular in its occurrence.

Below No. 6 coal should occur No. 5 coal, but the records that have been studied from this vicinity do not as a rule extend below No. 6. It

is possible that No. 5 may occur under this region as it does further west in the county, but presumably it is too thin to be worked profitably. Elsewhere it has beeen found some 60 to 70 feet below the Blue Band coal, and in one test hole northeast of Duquoin it has been found 64 feet below No. 6, where it had a thickness of only one foot.

The Blue Band coal, or No. 6, is found at depths ranging from 45 to 470 feet (see table No. 1). It varies in thickness from 5 to 13 feet 8 inches, averaging about 6 feet 2 inches as shown by measurements made in the mines. It is characterized chiefly by the development of a band of shale or clay that is highly impregnated with sulphide of iron, in places being nearly pure iron pyrites. This has been called the Blue Band, and from it the coal derives its name. The band varies in thickness, but as a general rule seldom measures less than 1 inch or more than 2 inches. Its position is also somewhat variable, but it generally lies about 18 inches above the fire clay floor. There is another band that occurs about 24 inches from the top of the coal, and generally consists of iron pyrites.

These two bands divide the coal seam into top, middle and lower benches which differ somewhat in physical character as well as in the amount of sulphur and in B. t. u. values.

Over the coal there is usually a band of shale known as draw slate. This varies in thickness, but seldom exceeds 10 inches. Above this occurs a shale usually light grayish in color, fine textured, and very hard. Its thickness is very irregular; in places it is entirely absent, and it may attain a thickness of 30 feet.

Above the shale occurs a ledge of limestone, dark grayish in color, and containing numerous fossils. It varies in thickness, and is reported in places to be as much as 18 feet. This limestone may be entirely absent over small areas. It often happens that in the same mine the limestone may occur above the coal with or without an intermediate shale. It is known locally as the roof limestone, or "cap rock."

Structure.

An unusual structural feature for this part of the State occurs at Duquoin, and its true character has beeen misunderstood by many. West of the Illinois Central main line the coal lies at shallow depths beneath the surface, but to the east it is reached only by deep shafts. This condition and the fact that the coal is thicker to the east has lead to the erroneous idea that two distinct coals are mined on the east and west. There now seems to be no doubt that the two are identical, and that the difference in the depth to the coal near Duquoin is due to a dip of quite unusual magnitude for this part of the State.

The accompanying map is based on some sixty records of shafts and bore holes furnished by local operators. Levels were run, in the course of this study, to each of the locations so as to determine the elevation above sea level of coal No. 6. The contours are lines of equal elevation and the arrows indicate the direction of dip.

As near as the geologic structure can be made out from the explorations thus far made, it may be described as an irregular monocline, caused by the sinking of the formations on the east side of Duquoin. South of Duquoin there is a rapid dip of the coal to the east, and in a distance of two miles the coal had descended from about 400 feet altitude to sea level. North of town the dip to the east appears to be at a greater rate than that observed south of town—about 250 feet in less than a quarter of a mile. This, however, may be due to faulting. The dip northward from Duquoin is very gentle, averaging about 12 feet to the mile. Nothing definite is known about the amount of the dip westward but it seems more than likely that there is a very slight dip for some distance to the west. Thus in and around Duquoin a small irregular domelike structure has developed and is represented by the 400-foot contour.

Some faulting has taken place in this area. A northwest-southeast fault occurs in the Queen mine and probably occurs under the west property of the Paradise mine. Outside of the immediate area other faults are known to occur. At the White Walnut mine one has been encountered crossing the east and west entries about 1,500 feet from the shaft. It is a normal fault with a throw of 32 feet to the east, the strike being nearly north and south.

The domelike structure and the high monoclinal are suggestive of conditions favorable for the accumulation of oil. From the drill records it appears that the sandstones necessary for holding oil are also present. But it may be that the faulting which has taken place is extensive enough to allow the escape of such accumulation. The extent to which the sands are full of water is unknown. The heavy Pottsville sand running down 311 to 489 feet in depth in the drill record quoted, is reported to carry fresh water, which is so far unfavorable. Salt water is reported in several of the lower sands. From the map it will be seen that the boring already done was not at the highest point on the dome and there is perhaps some encouragement to be derived from this fact. In general the area has not been adequately tested for oil and gas.

Coal Production.

In Perry county there are twenty-one mines and in the immediate neighborhood of Duquoin there are eleven, as shown by the map and table. Those most modern in their equipment and having the largest tonnage are Paradise Coal & Coke Co., Duquoin Operating Co., Majestic Coal & Coke Co., and Brilliant Coal & Coke Co.

TABLE I.—*Altitude of No. 6 Coal at Mines in Perry County.*

No.	Company.	Mine.	¼ Sec.	Sec.	Twp. South.	Range. West.	Depth to Bottom coal No. 6. Feet.	Altitude shaft opening. Feet.	Altitude. bottom of coal. Feet.	Average thick-ness in inches.
1	Tamaroa & Little Muddy Coal Co	Little Muddy	SE	29	4	1	216	505	289	68
2	St. Louis-Coulterville Coal Co	East Mine	NW	18	4	4	282	520	238	84
3	Avery Coal & Mining Co	Bald Eagle	NW	25	4	4	251	565	314	84
4	Bailey Bros. Coal Co	Sun	SW	20	5	1	85	469.1	384	60
5	Diamond Fuel Co	Diamond	NE	30	5	1	80	461.9	381.9	62
6	Perry County Coal Co	Perry	NW	32	5	1	82	450.7	368.7	65
7	Imperial Coal & Mining Co	Imperial	SW	32	5	1	80	453.6	373	64
8	Orion Coal Co	No. 5	NE	36	5	2	60	455	395	70
9	Strait Coal Co	Strait	SW	13	5	3	92	401	309	74
10	Bessemer Washed Coal Co	White Walnut	NW	25	5	3	98	446	348	72
11	Duquoin Coal Co	No. 3	SW	6	6	1	71	454.3	383	72
12	Orion Coal Co	No. 1	NW	8	6	1	60	460.7	400	72
13	New Moon Mining Co	New Moon	SW	9	6	1	50	451.9	401.9	78
14	Paradise Coal & Coke Co	Paradise	NE	15	6	1	380	409	29	96
15	Duquoin Operating Co	Queen	SW	15	6	1	312	410.9	98.9	72
16	Brilliant Coal & Coke Co	Horn	NW	19	6	1	80	440	360	66
17	Majestic Coal & Coke Co	Majestic	NW	23	6	1	412	402.5	–9.6	108
18	Wilson Bros. Coal Co	No. 1	SE	5	6	4	111	496.1	385.1	72
19	Johnson-Allen Coal Co	Barnard	SE	6	6	4	120	498.1	378.1	72
20	Willis Coal & Mining Co	No. 1	NW	30	6	4	86	503.3	417.3	72
21	Missouri & Illinois Coal Co	No. 4	NW	30	6	4	72	498.9	426.9	72

With one exception the coal is hoisted to the surface through shafts. The New Moon Mining Company operates a slope. The shafts are of double compartments, usually varying in width, but most commonly either 9 by 14 feet or 9 by 18 feet. The mines are laid out on the room and pillar plan, with modifications permitting the mining of coal most economically. Shooting off the solid prevails, although one mine has equipment for machine mining. Mule haulage is most general, but one mine has electric and another gasoline haulage. All large mines are equipped with shaker screens, and a number have a revolving screen for rescreening the smaller sizes. One mine is equipped with a washery.

The chemical character and heating value of the coal is indicated by the accompanying figures. These are derived from careful samples collected by the Survey from three typical mines. They represent the full thickness of the seam and include the total moisture present. For comparison, similar figures are given for this same coal bed as mined in the Belleville region to the northwest and in Williamson county to the southeast.

Locality.	Total moisture.	Dry Coal.		
		Ash.	Sulphur.	B. t. u.
Duquoin[1]	10.42	13.47	2.74	12,336
Belleville district[2]	12.30	11.72	4.04	12,500
Williamson county[3]	8.67	10.23	2.17	13,057

Coal has been mined in this country for many years, and as early as 1863 it was shipped over the Illinois Central to points north of Duquoin into Champaign and Chicago. No accurate data on production is to be had for these early years, but since 1882 the Bureau of Labor Statistics has collected the data, and David Ross, secretary, has kindly furnished the figures below. The total coal production for Perry county to the present year amounts to 20,447,349 tons, valued at $16,160,306.00. It is interesting to note that the aggregate value of the coal has increased with the total tonnage each year, with two exceptions. In 1895 and 1905

[1] Average of 3 samples.
[2] Average of 21 samples. Ill. Geol. Surv. Bull. 8 p. 254.
[3] Average of 11 samples. Ill. Geol. Surv. Report in progress.

the aggregate value fell below the tonnage, interrupting the relative rate of increase. During this period the average value of lump coal has increased 90 cents to $1.19.

Year.[1]	Total tons produced all grades	Average value at mines of lump coal per ton.	Aggregate values total tons all grades.
1882	276,845	$0.90	$ 249,160
1883	299,305	.98	293,319
1884	255,868	.98	250,750
1885	259,375	.979	253,928
1886	213,112	.934	199,047
1887	319,552	.877	280,471
1888	306,235	.942	288,473
1889	381,347	.945	360,648
1890	497,768	.880	438,396
1891	604,152	.88	459,129
1892	461,068	.87	340,182
1893	860,151	.95	679,484
1894	530,490	.94	417,966
1895	587,444	.80	373,809
1896	726,507	.72	523,085
1897	689,921	.679	410,071
1898	845,329	.765	522,637
1899	879,422	.782	537,085
1900	680,653	.84	462,965
1901	664,278	.956	539,866
1902	789,625	.95	656,078
1903	1,031,751	.956	977,140
1904	1,250,174	1.213	1,152,660
1905	1,26 ,718	1.173	1,111,867
1906	1,443,926	1.123	1,347,235
1907	1,743,922	1.194	1,625,217
1908	1,610,411	.875	1,408,763
	20,477,349	.78[2]	$16,160,306

[1] Fiscal year ending June 30.
[2] Average value per ton of total produ .

CASTS OF FORAMINIFERA IN THE CARBONIFEROUS OF ILLINOIS.

(By RUFUS MATHER BAGG, JR., Instructor in Geology, University of Illinois.)

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GENERAL DESCRIPTION.

While investigating some Coal Measure clays of the Upper Carboniferous at Georgetown, Illinois, the writer discovered that at least two of the clay strata subjacent to the coal seams contained a fair sprinkling of glauconite-like grains. It appears strange that these greenish grains have never before been observed, since they are visible to the unaided eye and are scattered rather abundantly though irregularly through the clay beneath the coal seams, designated as Nos. 6 and 7 of the Illinois series. These greenish granules are perfect casts of foraminifera, chiefly of Endothyra baileyi (Endothyra bowmani, Phillips) and, while the original shell substance is entirely removed, the septation of the forms has been preserved in detail.

Not only are many of these casts duplicates of the Endothyra bowmani, Phillips, but in addition there are several other planospiral types resembling the Nonionina group of recent oceans but which presumably represent either Lituola or Trochammina.

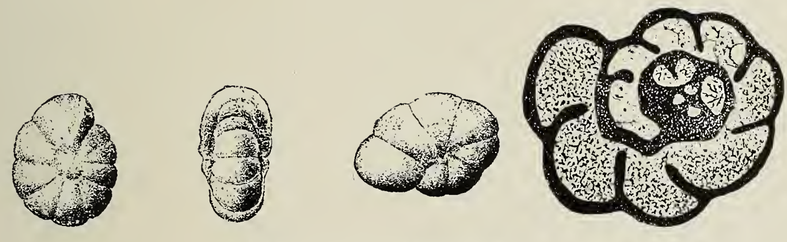
Since Ostracoda are common in the upper Paleozoic of the middle west it is quite probable that some of the casts represent this group, but they would be difficult to recognize owing to the unchambered condition of the original organism.

These grains, when seen under the microscope in cross section, possess either calcitic nuclei or iron pyrite (Marcasite?) centers of irregular form. These nuclei effervesce in cold hydrochloric acid and leave a cavernous structure in the interior which represents in part the original shell chambering.

Where the material is marcasitic a very dark, almost greenish border encloses the nucleus (Ferrous sulphate ?) and the outer margin is of olive green color like the New Jersey green sand.

It is supposed that these pseudomorphs, at least where the iron has replaced the shells, were formed in situ and that the replacement of the foraminiferal substance was very gradual after the entombment of the organism in its final resting place.

This central nuclear replacement in the case of calcite is quite in contrast with that of the New Jersey cretaceous glauconite which shows an olive green center and a darker exterior. We infer therefore that these particles in the Carboniferous formed very slowly and steadily after the entombment of the organism. The segregation of the calcitic or iron material forming a portion of the original test was in some cases protected from ultimate decay by the encasing ferrous sulphate (?) border which is insoluble in cold hydrochloric acid. In this case the shell was removed probably by percolating waters at a subsequent



Enlarged Views of Endothyra baileyi.

(Indiana Geological Survey.)

date or was entirely replaced by the inflling substance. The Carboniferous glauconitic pseudomorphs differ from the New Jersey greensand in that they have not been subsequently enlarged by accretion. There is a remarkable uniformity in the size of the granules and the Carboniferous material was never rolled like the New Jersey glauconite. An analysis of the New Jersey greensand grains selected and analysed by T. Sterry Hunt gave the following:

SiO	50.70
FeO_2	22.50
MgO	2.16
CaO	1.11
Al_2O	8.03
KO_3	5.80
Na_2O	0.75
N_2O	8.95
	100.00

The Silurian glauconite analysed by Hunt contained less iron and more alumina than that of the New Jersey Cretaceous.

In discussing the New Jersey cretaceous glauconite beds Bagg states:[1] "It is an interesting fact bearing on the origin of greensand that the writer has frequently found shells of foraminifera filled with glauconite. This is especially noticeable in Polymorphina communis, which in some cases where the shell is broken away, shows the interior filled with light green glauconite still bearing upon its outer surface the smooth impress of the shell. Many Cristellariae are partially filled with a light brown clay suggesting the early stage in the formation of the glauconite grain."

The important data of the New Jersey cretaceous which bears upon the present report is contained in the next paragraph: "It is perhaps rather remarkable that among so many grains of glauconite so few perfect casts of foraminifera are found and so small a number of intermediate stages, but it must be remembered that the shell-wall of the form is always thin and easily destroyed through solution in the percolating waters of such porous beds." * * * "From the size of the glauconite grains and the peculiarity of their shape it is probable that the glauconite has grown by accretion around an original nucleus, so that the outline of the delicate shells is only exceptionally preserved. Transverse sections of the glauconite grains show a difference in color and texture between the internal and external parts, the inner portion being of a light olive green and softer than the dark green irregular border."

It will be seen from the above therefore that in both these points, namely the lack of secondary enlargement and the absence of erosive action upon the grains at the time of their deposition the carboniferous material differs from the greensand of the cretaceous series.

[1] The Cretaceous Foraminifera of New Jersey. Bulletin U. S. Geol. Survey No. 88, 1898. p. 13.

The carboniferous foraminifera were embedded in very fine silt-like clay where the decomposition of the test went on so slowly that the substitution of the pseudomorph iron compound had sufficient time to fill the entire shell before the superstructure was removed in solution.

The upper stratum of clay beneath the so-called No. 7 coal seam is massive, plastic and where measured was over six feet in thickness. The glauconitic like granules do not appear to be confined to any given layer of this clay. The lower clay nearly one hundred feet below is five feet in thickness, is darker in color, full of slip planes and carbonaceous matter and is more indurated. It is heavier, but it contains the same types of granules found in the series above. This lower clay looks more like a fire clay than the upper stratum, though it is not highly refractory.

The water in which these foraminiferal shells were deposited must have been very quiet and sufficiently out from shore to escape wave action or the delicate granules would have been abraided and in such erosion the septal markings of the test would have disappeared.

Conditions of Deposition of Glauconite.

Glauconite is supposed to represent an off-shore deposit of considerable depth. It forms today in limited amount in the marine waters off Cape Hatteras as shown by Prof. J. W. Bailey[1] where the greensand fills the shells of Rhizopods and corals at depths of from forty to fifty fathoms.

Glauconite is moreover deposited near the mud line adjacent to coasts and is usually found along the higher portions of continental slopes where land derived materials are available and are deposited in perceptible yet small amounts. According to Murray and Renard,[2] greensand covers about one million square miles of the sea floor and while generally occurring at from one to two hundred fathoms has been noted at depths ranging down to 900 fathoms.

Ehrenberg,[3] the father of microscopical science, was the first to point out the connection of glauconite to foraminifera.

Murray and Renard in the challenger reports above referred to, offer the following well known explanation of the origin of greensand on the supposition that the chambers of the organism first become filled with a muddy sediment.

"If we admit that the organic matter enclosed in the shell, and in the mud itself, transforms the iron in the mud into sulphide, which may be oxidized into hydrate, sulphur being at the same time liberated, this sulphur would be oxidized into sulphuric acid which would decompose the fine clay, settling free colloid silica, alumina being removed in solution, thus we have colloid silica and hydrated oxide of iron in a state most suitable for their combination."

Glauconite does not form where sedimentation is rapid and it is supposed that its formation is favored by considerable changes in temperature.

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[1] J. W. Bailey "On the Origin of Greensand and its Formation in the Oceans of the Present Epoch," Proc. Boston Soc. Nat. Hist. Vol. V, 1856, pp. 364-368.

[2] Challenger Reports, Deep Sea Deposits, see pp. 167-172.

[3] Abhandlung d. k. Akad. Wissensch. zu Berlin, 1855, pp. 85-176.

Dr. W. B. Clark[1] very briefly discusses the origin of greensand in a paper entitled, "Origin and Classification of the Greensands of New Jersey." Regarding the conditions of deposition of the New Jersey greensands, Clark states that these glauconite formations were probably laid down at a distance of from fifteen to thirty miles off shore and at very moderate depths. Clark points out that greensand is not an original deposit, but requires both inorganic rock constituents and the presence of foraminifera.

The rock making minerals mentioned include quartz, magnetite, feldspar, hornblende, augite, zircon, epidote, tourmaline and garnet. In the carboniferous clays the clay constituent predominates but we note in addition to minute quartz fragments, magnetite, and other massive rock constituents.

The pseudomorphs of iron resembling glauconite of the carboniferous seldom exceed one millimeter in diameter and the average will probably be much less than this. From the addition of a phosphatic cement the grains may, however, attain a diameter of several centimeters. The carboniferous material possesses a nearly uniform dark green color which persists throughout the entire mass save for the calcite or marcasite nucleus. A section of the locality where this material was discovered is given on the following page.

Glauconite occurs in many formations such as the Cambrian of Wisconsin and Russia, the Calcaire Grossier (Middle Eocene) of France, in the Tertiary Zeuglodon beds of Alabama, but it is particularly developed both in Europe and in America in the Upper Cretaceous. In England, the Lower Cretaceous greensand overlying the Weald clay is from 250 to 450 feet thick. The New Jersey Upper Cretaceous greensand series have a maximum thickness of over 200 feet and if we include the clay marls, which are partly glauconitic, attain a total of about 500 feet in the Atlantic Coastal Plain belt.

While conditions may have re-occurred again and again throughout past epochs in which glauconite could have been developed it seems to be rare in Paleozoic time if we expect the Cambrian and perhaps Precambrian deposits of the iron region north of Lake Michigan.

Prof. C. K. Leith,[2] in his paper on the "Genesis of the Lake Superior Iron Ores" described the hydrous iron silicate resembling glauconite under the term Greenalite. Leith states, "The greenalite granules, believed to have constituted the bulk of the original Mesabi iron-bearing formation, are similar in physical and optical properties to glauconite or greensand, but differ in almost lacking potash. "They have been called glauconite by Spurr,[3] who argues that the absence of potash may be due to secondary alteration and that in any case the composition of glauconite, as far as determined, is so variable and uncertain as to warrant the application of the name to the Mesabi granules, so similar to glauconite in physical and optical properties."

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1 Journal of Geology Vol. II., 1894, p. 161.
2 Economic Geology, Vol. I, No. 1, 1905. p. 64.
3 Geol. and Nat. Hist. Surv. Minn. Bull. X. (See also Amer. Geol. Vol. xxix).

Origin and Composition of the Carboniferous Granules.

The composition of the pseudomorphic material which has substituted the foraminiferal shell in the carboniferous was thought at first to be a form of glauconite. Since tests for potassium failed to reveal this element which is essential in glauconite it was thought that the substance might be similar in composition to the greenalite of the mesabi iron district as described by Dr. C. K. Leith.

The carboniferous material was therefore analyzed in the chemical laboratory of the University of Illinois and was found to have the following composition:

	Per Cent.
FeS_2	10.84
Fe_2O_3	54.10
Al_2O_3	2.20
SiO_2	3.80
CaO	trace.
MgO	1.80
Loss on ignition	33.69
	106.43

In the analysis given by Dr. Leith on the Mesabi Greenalite the mineral is shown to be mainly silica, ferrous iron, magnesium oxide and water. The ratio of four analyses calculated on the basis of 100 is given on page 114 of the Monograph No. XLIII the Mesabi iron-bearing district and is as follows:

	1	2	3	4	Average.
SiO_2	45.1	43.7	47.7	40.2	46.8
FeO	42.1	47.7	44.6	50.9	46.3
MgO	2.8	8.8	7.8	8.9	7.1

From this the theoretical proportion of the ferrous iron to the silica would be silica 45.62 and ferrous iron 54.38 per cent.

If we assume from the above that the ferrous iron should approximate 54.38 per cent we find the amount checks closely with the carboniferous pseudomorphs from Illinois, but in Greenalite the granules show only 0.56 per cent of alumina and a high content of silica. In the carboniferous grains FeS_2 must represent the marcasitic nucleus and the ferrous iron which surrounds this center is darker colored from organic matter and presumably this matrix contains iron in ferrous sulphate form. The protoxide of iron would largely account for the greenish color of the entire granule. The substance would not appear then to be greenalite since it differs from that mineral in its silica content.

It agrees with it in lacking potash, in having a corresponding amount of magnesia and in containing only a trace of calcium. It differs from glauconite in lacking potash and in possessing a low alumina and silica content.

Were these greenish particles as well rounded as the New Jersey glauconite, which show no septal marking, we might argue that they had been formed by a redeposition of the oolitic material containing Endothyra. This could be explained by supposing the shells to be rapidly filled with clayey substance at the time of their deposition and the alteration into concretionary form to have occurred at a later date.

In the case of oölitic limestone we do not have a rock which would redissolve and be transported from Mississippian beds into carboniferous clays of the coal strata. It is more probable that the foraminifera lived in the shoal carboniferous ocean and that after the deposition of their shells the iron compounds replaced the original substance.

It is not difficult to imagine the continued existence of microscopic Protozoan life from the Lower into the Upper Carboniferous epoch, since the power of locomotion is well developed in Protozoa and the rapidity of reproduction would enable the forms to survive a few adverse conditions.

Probable Conditions of Deposition.

The reappearance of the glauconite-like granules subjacent to two coal seams nearly 100 feet apart reveals a similarity of conditions which were repeated. The intervening time was sufficiently extended to allow about one hundred feet of thin bedded shale to be laid down.

SECTION WEST OF GEORGETOWN.

Material.	Thickness.	
	Feet.	Inches.
Soil	2	....
Glacial clay	8	....
Calcareous shale	129	....
Coal (No. 7)	3	10
Plastic clay, with pseudomorphs resembling glauconite	6	....
Calcareous shale, fine bedded	80	8
Thin shale and coal seams	5	....
Coal (No. 6)	5	6
Slip clay, with pseudomorphs	5	....
Total	245	....

From the section already given it will be noted that above the clays containing the pseudomorphs resembling glauconite there are two coal seams, the lower one 5½ feet thick and correlated with "No. 6" and an upper bed 3 feet 10 inches thick, some 100 feet higher up in the section. The base of these two coals is sharply defined by a definite plane from

the subjacent clays. There is, therefore, no gradual transition from the clay into the coal strata, and, while we infer that the conditions were similar in each deposit, the interval required for the deposit of the lower coal bed was almost double as long.

Again it is not necessary to suppose that the ocean was at this period of great depth. As bearing on this point it is interesting to note that John Murray[1] states: "I am inclined to the view that in Paleozoic times the ocean basins were not so deep as they are now, that the ocean then had throughout a nearly uniform high temperature, and that life was either absent or represented only by bacteria and other low forms at great depths, as is now the case in the Black Sea, where life is practically absent beyond 100 fathoms and where the deeper waters are saturated with sulphuretted hydrogen."

Even if we assume a depth of 100 fathoms during the deposition of these carboniferous clays we should require a movement of over 600 feet downward after the formation of the No. 6 coal seam and that in comparatively short time which was again followed by an almost equal elevation in order to elevate that 100 fathom clay where glauconite was being deposited to near the sea level in order that coal plants could again develop profusely.

It seems, therefore, much more plausible to assume that the foraminifera were living like the Textulariæ of today near sea bottom at very shallow depths and that the fine silt-like sediments washed in near shore a number of the Endothyra types, where they were rapidly buried in the clay strata close to the margin of the sea shore.

Under this theory a slight increase in submergence immediately prior to each coal formation is possible, and this would be followed by a somewhat longer period of stationary sea border adjacent to a base-level continent over which an epicontinental sea was very slowly encroaching.

Summary.

The conclusions we reach, therefore, regarding the formation and deposition of the glauconite-like material is as follows:

1. Foraminifera of Subcarboniferous (Mississippian) types continued their existence in Upper Carboniferous time.

2. These genera existed in shallow waters and were preëminently bottom types of subarenaceous species which lived near the margin of sea-coasts in only a few fathoms of depth.

3. Their shells were deposited contemporaneously with the clay strata in very quiet water below tidal action bordering a base-leveled region.

4. The marcastic and ferrous sulphate infiltration in the tests of the foraminifera was subsequent to their deposition in the clays and the process was both gradual and the infilling complete within the shell cavity.

5. Subsequent removal of the external shell either by solution from the percolating waters or a partial replacement of the shell substance which was largely of the arenaceous foraminifera type.

[1] Scottish Geographical Mag. Vol. xv. p. 514.

6. Immediate elevation of the land above sea level as evidenced by the sharp demarkation of the coal strata overlying these clays and which elevation was of sufficient time length to allow in the lower seam 5 feet 6 inches of coal to form and in the upper layer 3 feet 10 inches of coal to originate.

7. Return of submergence conditions after deposition of some 100 feet of thin-bedded shale between the two coal seams.

8. A gradual deepening of the sea followed by a redeposition of foraminiferal forms which had again migrated to near the border of the sea shore after a time interval represented by from 90 to 100 feet of sedimentation.

These conclusions are only suggestive from a general survey of the above outlined data and it is thought that further study upon additional material from other localities may throw additional light upon the distribution of the foraminiferal life in Illinois during the Carboniferous period and perhaps upon the formation of glauconite. With the freshening of Carboniferous waters during the coal bed formation it is likely that a withdrawal took place of the Foraminiferal types into deeper waters which would more nearly resemble those of existing oceans. Still we must not forget that the Endothyra and other Rotaline types in the Paleozoic epochs were more usually arenaceous, the calcareous porcellaneous and perforate calcareous types developing more fully in Mesozoic oceans.

NATURAL GAS IN THE GLACIAL DRIFT OF CHAMPAIGN COUNTY.

(By Carl F. Knirk.[1])

In Champaign county, as elsewhere in the State, the occurrence of gas in comparatively shallow wells is reported so frequently as to arouse much curiosity. The State Geological Survey is continually receiving queries as to the sources, extent, distribution and value of the gas. With a view to answering these questions this work was undertaken by the writer and considerable information was collected during the summer of 1908. The city of Champaign is in Champaign county, in the east central part of the State, about 128 miles south of Chicago. All points visited in this work are within fifteen miles of Champaign, and nearly all of them are south of an east-west line drawn through the city.

The most striking feature of the topography of the region is its levelness, as may be seen from the Urbana and Mahomet contour maps. The extreme relief is less than 200 feet, and the average elevation above sea-level is about 700 feet. The absolute monotony of the topography is broken by the small glacial moraine which extends from northwest to southeast across the area. This moraine can be seen to the northwest of Champaign where it is known as the Yankee range. It passes to the east of Champaign as a narrow belt of irregular hills, thence to the southeast and south of the city, where it bends abruptly to the east. Just south of the city the University farm and Urbana cemetery are located on it. From the cemetery it takes a direction a little to the east of south and leaves the Urbana quadrangle at Philo, where it is again known as Yankee Ridge. To the east of Urbana a medial moraine or spur was developed, which extends toward the east of north through the gravel beds north of Urbana, thence some 2½ miles east of Leverett, and on past Thomasboro, some two miles east of town. Aside from the moraines mentioned the land is so level that it has to be artificially drained before it can be used for agricultural purposes.

A large number of wells that yield more or less gas are located on the southern slope of the moraine or on the outwash area beyond it. The well on Senator Henry M. Dunlap's farm, the best known and most important well in the area, is located on the outwash plain. Mr. Walter Hall has a well thus located on his farm 2 miles north and three-quarters of a mile west of Savoy. In Sommers township a well, with a reported gas pressure of fourteen pounds, is located near the medial moraine.

[1] The University of Illinois; Department of Geology.

Other wells, similarly located ,are as follows: One three miles southeast of Mahomet on the W. Rayborn farm, where gas was found at a depth of 150 feet;[1] one five miles northwest of Champaign, where gas was found at a depth of 135 feet;[1] and one two miles south of Boonville on the Norton farm, which struck gas 100 feet below the surface. Other wells occur, some of them on or near the moraine, while other seem to bear no relation to surface topography. One well, located away from the moraine, 2 miles east and 1½ miles south of Sidney, has yielded a little gas for a number of years. Strange to say, this is the only well in this neighborhood that has ever given out any gas, although many others are equally deep. It is not probable that the gas occurrences bear any direct relation to the surface features, although many of the wells are so situated as to suggest an indirect relation.

The gas is encountered in many wells drilled (or dug) for water, but there is no certainty that either gas or water will be found at a given depth or indeed at any moderate depth. Both alike depend upon the irregular arrangement of the glacial deposits of this area, and both are confined to certain porous channels. The water wells vary from 15 to 297 feet, but are commonly between 80 to 160 feet deep. In many instances a well, 50 or 60 feet deep, supplies an abundance of water, while another well, only a few feet or rods from it, has to be put down to a depth of 150 or more feet before any water is encountered. Indeed, the testimony of every well driller in this region is, that he can tell nothing about the probable depth at which he will find water in a given place by knowing the depth of the wells in the immediate neighborhood.

The gas is reported to occur in or near beds of black, mouldy soil containing remains of plant life. Evidences of forest beds is common. In the coal shaft, which was at one time sunk in Urbana, a stick four inches in diameter was found. A piece nine feet long was cut off from the stick and divided among several of the men who saw it removed. The writer has a piece of this timber, about four inches long, which has been identified as a close relative of Picea alba. Mr. P. Vance, of Urbana, says, "It is quite common for us to find wood at a depth of from 90 to 120 feet, and we always find a black soil associated with the gas." Mr. W. R. Nightingale, of Champaign, says, "Gas is often found at a depth of 100 feet in a green sand, or a black mud, and in one instance, on the Fry farm west of Champaign, a piece of wood, three feet long, was removed from a well 140 feet deep. He also states that he has found wood in no less than 30 or 40 wells. At the Cunningham farm, an eight inch stick of wood was encountered in an open well at a depth of 42 feet. In another instance gas forced out "pieces of dry, rotten wood, which looked like cork." Since the material below and above the vegetable remains is of glacial origin, and since the vegetation is common at certain levels, it seems that the glacial occupation was interrupted by one or more periods of mild climate during which vegetation flourished and accumulated in favorable situations. With the re-advance of

[1] Reported by Mr. W. R. Nightingale, Champaign

the ice the vegetation was buried beneath a mass of clay, sand, gravel, bowlders and ice. There may have been only one or two, or there may have been several such oscillations.

During the retreat of the ice and in the interglacial period, the waters from the ice and subsequent rains must have formed into streams in many places. These flowing waters must have developed river systems; the perfection of which depended on the amount of rainfall, the period of time before the glacier advanced over the region again and other factors. Since the indications are strong that vegetation had time to spread over the area and develop forest remains, it is reasonable to suppose that some of the interglacial periods were comparatively long. During these periods, well defined river channels were, no doubt, developed. With the re-advance of the ice, it is quite possible that these channels were filled with sand and gravel by the over loaded streams from the ice. If these channels were thus filled, and if the advancing ice was depositing its load, rather than eroding, underground sand and gravel veins would be formed. Whether this is the true explanation or not, the fact nevertheless remains, that there are well defined underground veins of sand and gravel in which most of the water and gas of this region is found. Wherever these veins yield gas they are overlain by a very hard clay, or "hard pan," which serves as an impervious cover for the pressure of the accumulating gas. Such gas as may possibly occur in porous veins or pockets which are at a distance from forest beds probably represent leakage from such beds.

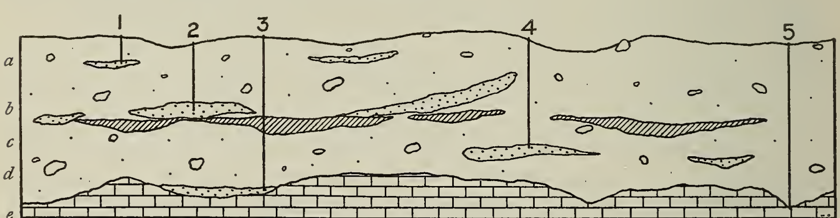

FIG. 5.—Diagramatic section showing relations of wells which penetrate: *a*, late drift; *b*, sand pockets; *c*, old soil; *d*, early drift; *e*, bed rock.

The accompanying theoretical cross-section, Figure 6, shows more or less well defined veins of sand and gravel in a bed of bowlder clay. It will be seen that the depth of a well depends on its location with regard to the underground sand and gravel vein. If such a well happens to strike a vein which is favorably located for the production and preservation of gas, it may produce gas. Some of these sand-filled underground channels may connect with large areas in which considerable organic material is decomposing and hence may produce gas for a long period of years.

It seems that the gas must originate from the decomposition of organic material in the glacial drift, for the following reasons:

1. In practically every case where gas has been found, it is reported that rotten wood and other organic remains have been found in the gas sand.

2. It is found chiefly in the sand channels which are overlain by clay.

3. The gas frequently dies down in a short time, which indicates a limited supply and probably a local source.

4. There is no evidence that the gas comes from deep seated reservoirs. It may be found in a certain vein of sand and a well pushed through this level to a lower sand may fail to find gas. In at least two places, deep bores have been made in testing for gas. Mr. George Douglas, who lives some four miles south of Urbana, drilled to a depth of 1,000 feet and failed to find gas in the underlying rock. A second boring, without results, was made to a depth of 580 feet, near the present Green Street Subway in Champaign.

5. The gas wells frequently coincide with surface features, but bear a more direct relation to underground gravel veins, probably of interglacial origin.

6. Peat bogs give off gas at the present day, and instances are frequent elsewhere of gas occurrence in old buried beds of forest remains.

Because of the small supply and the light pressure the gas never has been and, undoubtedly, never will be of much economic value. Locally, it is being used successfully by Senator Dunlap and Mr. Walter Hall in their country homes for heating and lighting purposes. In several other instances it has been used for a time, but the wells required so much attention that the owners soon abondoned them. Elsewhere in the State similar wells have been adequate for home supply for a few years.

ARTIFICIAL SILICATES WITH REFERENCE TO AMORPHOUS SILICA.

(By W. S. WILLIAMS.)

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INTRODUCTION.[1]

GENERAL.

In southern Illinois there are large deposits of amorphous silica which have been worked but little. This fine grained, white, substance is used as a filler for wood, for paints, for scouring soaps, toilet powders, porcelain bodies and glazes. These deposits are being worked by several firms at present, practically all of the mining being done by hand. The preparation consists of fine crushing and of careful sizing of the material. The supply far exceeds the demand and the effect of opening these recently discovered deposits has been to overstock the market and lower the price of amorphus silica.

The geology of this region is not very well known. Mr. F. W. DeWolf visited this territory in 1906 in the interests of the State Geological Survey and made preliminary observations on the geological formation and also collected samples. He states that the material occurs as bedded deposits, varying in thickness from a few feet to six or eight feet. A preliminary report is found in Bulletin No. 4 of the Illinois State Geological Survey. The following table shows the chemical analyses of the samples collected, as reported in the above mentioned bulletin:

TABLE No. 1.

Number.	SiO^2.	Per cent Fe_2O_3 Al_2O_3	Loss on Ignition.
203	87.90	3.72	2.84
204	82.26	6.04	1.76
205	95.14	2.38	....
206	90.24	5.88	....
207	95.18	1.04	....
208	90.04	2.36	....
209[2]	73.78	14.56	5.43
210	97.20	1.28	....
211	95.78	1.80	....
212[2]	77.82	10.26	....

[1] Presented as a thesis to the faculty of the University of Illinois for the degree of B. S. in chemistry. The work was done under the direction of Prof. S. W. Parr, on whose suggestion it is included in this Year Book.

[2] NOTE—Iron and alumina were separated in 209 and 121.

ACKNOWLEDGMENTS.

Acknowledgment is due to Mr. C. F. Hagedorn, a graduate, of the University of Illinois in 1905, who in the fall of that year began a line of research in an attempt to make siliceous bricks; and to Mr. C. H. McClure, who subsequently took up the work and made a few determinations of lime and silica. Neither of these men carried this particular work further. Mr. H. B. Fox, in tests on sand-lime brick, used the samples made by the above men. The next person to take up this interesting work, was Mr. T. R. Ernest, working under the direction of Prof. S. W. Parr, in the laboratory of Applied Chemistry, of the University of Illinois. He had three objects in view in his investigation, viz.:

1. To study the sand-lime brick process, including a review of the literature and experiments.
2. To study the compound formed by the action of high pressure steam on mixtures of lime and silica, from both the chemical and physical standpoint.
3. To find uses for Illinois silica.

In this thesis, Mr. Ernest shows that the chemical compound formed by the action of high pressure steam on intimate mixtures of lime, and silica is probably the mono-hydro calcium silicate which may be considered analogous to the meta silicate Wollastanite ($Ca\ O$, $Si\ O_2$), with one molecule of H_2O of hydration. He also states that the best proportions in mixing are equal parts of lime and silica. In running fire tests on this mixture he did not measure the temperatures but found that the mixture cracked badly in a suddenly heated muffle furnace.

SCOPE OF THIS WORK.

The object of these investigations is to determine by means of the tensile strength:

1. The proper ratio of lime to silica to form the strongest bond.
2. To improve the texture of the mixture by suction, boiling and using plaster of Paris molds.
3. To increase the strength of the mixture by adding fibrous materials thereto.
4. To determine whether the material can be molded into shapes which would be useful for architectural decoration.
5. To determine the effect of fire on this material.
6. To determine whether steam pressure is necessary and, if so, what pressure is most suitable to give the strongest bond.

Development of the Sand-Lime Brick Process.

It is a well established fact that a moist mixture of sand and slaked lime becomes hard on being exposed to the air, a process which depends upon the absorption of carbon dioxide. For many years "mortar-brick" have been made, dependent on this reaction. It forms calcium carbonate, which acts as the cementing material. The making of sand-lime brick with calcium silicate as a filler does not date back more than thirty years. In this a chemical combination takes place between the two constituents, slaked lime and sand, which binds the two together in a manner similar to vitrification.

SAND-BRICK WITH EXCLUSIVE CARBONATE FILLER.

It is readily understood that a stone with calcium carbonate as a filler is not as strong as one with a calcium silicate union.[1] Twenty to 40 per cent of completely slaked lime is added to sand and thoroughly mixed with sufficient water to allow easy molding. This is then hardened by one of three methods:

1. The brick is exposed to the atmosphere for a long time,[2] the caustic lime thus slowly acquiring the needed carbon dioxide $Ca(OH)_2 + CO_2 = Ca\ CO_3 + H_2O$. The necessity for complete slaking is quite evident since any unslaked lime would slake later and rupture the brick. The time required before use is five or six months, and a maximum strength is attained in one or two years. The hardening is similar to that of mortar and is only superficial. Zurick says that only 30 per cent of the lime in very old mortars has been converted into the carbonate.

2. Hardening in an atmosphere rich in carbon dioxide without pressure. This gives the same results as the first process but in much shorter time.

3. Hardening with carbon dioxide under pressure. For this process the advantage is claimed that nearly all of the $Ca(OH)_2$ is converted into carbonate. However, Prof. Rinne of Hanover does not believe that this is satisfactorily proven and he is of the opinion that the carbon dioxide will form a carbonate on the surface, closing the pores of the brick, and thus preventing the entrance of enough carbon dioxide into the body of the brick to make the conversion to the carbonate complete.

SAND-BRICK WITH CARBONATE AND SILICATE FILLER.

In this process the treatment up to the hardening point is the same as that just described but the hardening is effected in a warm moist atmosphere, saturated with CO_2. A combination of these methods provides for the introduction of CO_2 into kettles or closed iron cylinders used for steam hardening. Under the conditions first cited, the product has as a binding material for the most part $CaCO_3$, but some hydrated calcium silicate is probably formed, thus strengthening the bond. In the latter the binding material is mainly calcium hydrosilicate and the amount of carbonate is much less than in the former.[3]

SAND-BRICK WITH HYDROSILICATE FILLER.

This brings us to the third class, the only one which will ever be of any importance in the commercial world. The same raw materials are used as in the other proces, viz.: sand and lime. The subsequent paragraphs will be devoted to a review of the literature on this subject.

In present practice[4] one of four methods prior to hardening are employed, the different features being the method of preparing the lime:

1. Wet slaking process.
2. Dry slaking process.
3. Acid slaking process.
4. Quick lime process.

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[1] See bibliography, 16. [2] See bibliography, 1. [3] See bibliography, 13. [4] See bibliography, 8.

THE WET SLAKING PROCESS.

This process consists in slaking the lime to a fat putty and then mixing in the desired proportion of sand and water.[1] From this it is carried to bins over the press and allowed to stand a short time and then pressed.

With properly burnt high calcium lime, the addition of the proper amount of water can be made with enough labor. The heat given up by the union of caustic lime and water is sufficient to generate steam in the minute pores of the amorphous oxide and thus break it up into the smallest possible particles, constantly and rapidly exposing new surfaces to the hot water. Calcium oxide on hydration gives up 246 calories of heat per gram. Under these conditions the CaO seems to form a hydrate, carrying more than one molecule of water. The excess is locked so loosely that a little excess of heat, as would be the case with too little water, would prevent its formation. If there is insufficient water, the lime will become too hot, or be too dense, for the best results. The product of correct slaking is an extremely tough and plastic mass.

Walters found that the best slaking of high calcium lime gave an increase of 3.5 times the original volume, while air slaking gave 2.5 times, and slaking with a large quantity of water 1.7 times the volume. The increase in volume gives better spreading or enveloping power.

With the dolomites,[2] more time is required for proper slaking for the two following reasons:

1. The magnesium oxide is overburned at the temperature of complete expulsion of carbon dioxide from limestone and is hence above its point of maximum porosity.

2. The heat evolved by magnesium oxide on hydration is much less than that for the hydration of CaO. The presence of both acts in the direction of retardation. Pure dolomite lime yields 130 calories of heat per gram.

If this process is used it will be found advantageous to mix the lime into a cream which will favor its even distribution over the sand grains.

THE DRY-SLAKING PROCESS.

This differs from the preceding only in the fact that the lime is slaked with just enough water so that the heat of chemical reaction will dry the finished hydrate.[3] The hydration is incomplete in most cases. For sand-lime brick a steam-slaked lime is always safe, since the lime has reached the limit of expansion under the action of steam. Where magnesium lime is used this is the method which should be used because the dolomitic limes slake too slowly for any other process.

The fine state of division in which the lime hydrate is left after dry-slaking gives it the best possible physical condition for uniform distribution and chemical reaction. The dry hydrate can be rapidly and also completely incorporated into the sand and when water is later added there is but slight tendency to ball up.

THE ACID-SLAKING PROCESS.

In this process 5 to 10 per cent of a solution of hydrochloric acid, 19° Baumé, is added to the lime after slaking has begun.[4] This is the basis of a German patent issued to P. Kleber. In the preliminary slaking the

[1] See bibliography, 27. [2] See bibliography, 28. [3] See bibliography, 5, 27. [4] See bibliography, 8.

hydration is carried only from one-third to one-fifth of completion, so that only one-third or one-fifth of the lime is changed into calcium chloride.

This compound, as is well known, has a great affinity for water and is also very active in attacking silicates as is illustrated by its action in the nascent condition made use of in the J. Lawrence Smith method for the determination of the alkakies.

The introduction of calcium chloride would be objectionable since, if the chloride remains as such, it would later appear as an efflorescence because of its solubility. If it is decomposed, and calcium silicate formed, the acid liberated in the atmosphere of steam must surely attack the metal cylinders unless they are glazed or lined with lead. The reaction involved is:

$$Ca\,Cl_2 + Si\,O_2 + H_2O = Ca\,SiO_3 + 2H\,Cl.$$

THE QUICK-LIME PROCESS.

Description.—In this the dry calcium oxide is mixed with the sand and just enough water added to slake the lime.[1] The water is generally added in two portions, with a short interval between additions to give the lime time to absorb all the water possible. The production then goes to the press, but should not reach it until at least twenty minutes have elapsed, in order to give the lime time to slake. This appears to be the most rational and rapid method where the materials are available. There is no rehandling of any of the materials. The sand and lime start in together at one end of the plant and come out at the other a finished product without intermediate delay. This method is not adapted to the use of all kinds of limes, for it requires a sensitive, quick-slaking lime and one which therefore has not been overburned nor stored for any length of time. A sand containing considerable moisture can be used without disadvantage, since the absorption of water by the quick-lime will remove considerable moisture from the sand and the heat generated by slaking will aid evaporation. If the plant is properly arranged, the mixture will go through the press while still warm and into the hardening cylinder before cold. In this manner some steam is saved in the hardening process, since not quite so much steam is condensed in raising the temperature of the brick up to the temperature of the steam. The amount of steam condensed will, of course, be proportionately less, the higher the initial temperature of the brick.

Mixing.—The key to the success of the process lies in the thorough mixing of the constituents, and for this purpose nearly every known mixing device has been used.[2] The ones most extensively used today are: the Schwarz mixer, the pug mill, and the tube mill.

Pressing and Hardening.—In view of the nonplastic nature of the mixtures they do not flow evenly through a die, hence they cannot be used with a clay-brick machine. On the other hand, a dry-press for clay-brick must be greatly strengthened, in order to stand high pressures. After trials of all the various kinds of presses, the rotating table press predominates in Europe, while in America the preference is divided between the table-press and the upright dry-press.

[1] See bibliography, 13. [2] See bibliography, 14.

The hardening is accomplished by one or two methods, either by low pressure steam and long exposure, or high pressure steam and short exposure. In the former case about two atmospheres are used for seventy-two hours, giving a temperature of 125°C, and in the latter from seven to ten atmospheres for six to ten hours are used, giving a temperature of 170 to 185°C. This last is now universally used in the industry.

Experimental Work.

CONDITIONS OF THE EXPERIMENTS.

Test briquets were made in a standard cement briquet mold, using amorphous silica from southern Illinois and lime of a good commercial quality, which was slaked in the steam autoclave before adding to the silica. The batches were weighed on a scale sensitive to one-tenth of a gram. Then the ingredients of a batch were put into a dry ball mill and ground for at least two hours to insure perfect blending and homogeneity. After removal from the mill, the mixture was screened through a fifty-mesh sieve, mixed with water and then immediately molded into briquets. The amount of water used was sufficient to make the mixtures work well. The mixture of lime and silica was found to be nearly as plastic as Georgia kaolin. The amount of water necessary to gain this plastic state was found to be 250 cubic centimeters added to 500 grams of the mixture. By volume, this would be two parts mixture to one part of water. This amount was used throughout the experiments.

If the briquets were allowed to dry too rapidly, they checked badly on the drying surface. This was overcome by placing damp cloths over them. By this procedure the capillary system of the drying surface is kept open until the interstitical water of the interior of the briquet has dried out. Then the cloths were removed and the capillaries of the surface allowed to dry and close up. It was also discovered that if the briquets were too wet when steamed they would crack open and fall apart. This is due to the water of capillarity being converted into steam which, having no ready egress, bursts the form. Taking the above mentioned facts into consideration, it was determined to let the briquets dry for at least thirty-six hours before steaming them. This was adhered to during the course of this work. However, it must be understood that, if the unsteamed briquets are exposed to the air for too long periods of time, the carbon-dioxide of the air will react with part of the calcium hydrate to form the carbonate and thus the ultimate strength will be reduced.

After the briquets were steamed they were dried, and aged for a week. They were then tested for tensile strength on a standard Fairbank's automatic machine, such as is used in testing cement.

THE PROPER RATIO OF LIME TO SILICA TO FORM THE STRONGEST BOND.

Naturally the first consideration is to determine the effect of various per cents of lime and silica on the tensile strength; and, also, what proportion gives the highest tensile strength, or, in other words, the strong-

est bond. Accordingly, briquets were made up of different percentages of lime and hardened in the autoclave. Table II below shows the relations of lime to silica used and the results:

TABLE II.

Data:—Steam pressure, 105 lbs. per square inch. Time exposed to steam, 10 hours.

Per Cent Ca O.	Per Cent SiO_2	Tensile strength in lbs. per sq. in.
10	90	135
20	80	265
30	70	202
40	60	189
50	50	150

Table III illustrates the increase in tensile strength when a higher steam pressure is used:

TABLE III.

Data:—Steam pressure, 150 lbs. per square inch. Time exposed, 10 hours.

Per Cent Ca O.	Per Cent SiO_2	Tensile strength in lbs. per sq. in.
10	90	134
20	80	278
30	70	204
40	60	189
50	50	148

In Table IV is shown the decrease in tensile strength when a low steam pressure is applied:

TABLE IV.

Data:—Steam pressure, 50 lbs. per square inch. Time exposed, 10 hours.

Per Cent Ca O.	Per Cent SiO_2.	Tensile strength in lbs. per sq. in.
10	90	102
20	80	182
30	70	116
40	60	94
50	50	71

All of the above data are the averages of five or more tests. It is easily seen that the strength increases remarkably with the increase in the lime content, until twenty per cent of lime is reached, and then

falls almost as rapidly as it increased, when more than twenty per cent of lime is added. The tensile strength does not increase in the same proportion between 105 pounds pressure, as it does between 50 and 105 pounds pressure. These results were all verified by running tests in which the lime content varied by only three per cent instead of ten as given in the tables, and when the maximum point was approached the ratio of lime to silica were varied by only one per cent. The texture of the broken briquets was an open structure with frequent air holes. Assuming that this open structure could be eliminated and a more compact body formed, tests were run by the following methods:

(1) By mixing the constituents with sufficient water to form a cream and then exhausting the air from it. The creamy mass was then carefully poured into the molds so that no air was occluded.

(2) By boiling the air out of the creamy mass and proceeding as above mentioned.

(3) By pouring the viscous mixture into molds made of plaster of Paris.

Although many trials were made, the results were unsatisfactory. The averages of the trials made by the first method is only 213 pounds per square inch as against 278 pounds found in Table III. The second method yielded even poorer results, being 204 pounds per square inch. But the third method gave the best results, the average reaching 226 pounds per square inch. The failure of these methods to increase the tensile strength of the 20 per cent lime to 80 per cent silica mixture, hardened at 150 pounds per square inch, and exposed for 10 hours, is probably due to several causes. First, in none of the methods could pressure be applied while molding the briquet; second, in methods 1 and 3, the silica having a higher specific gravity than the lime, tended to settle out of the fluid while in the mold; third, while what has just been said above applies equally well to method 2, it is also very probable that the heat tended to start the chemical reaction between the lime and silica, and that this reaction was stopped by the molding period and hence the bond was weaker.

The texture of these briquets was very good with respect to the air bubbles contained and the compact nature of the body.

EFFECT OF ADDING FIBROUS MATERIALS.

Mineral wool, otherwise known as slag wool, was the first fibrous material added to the 20 per cent lime mixture. A series was run ranging from 2 per cent to 10 per cent of wool added. This did not increase nor decrease the strength but seemed to act as an inert substance.

The other substance investigated, having a fibrous stringy nature, which would be commercially feasible, was cheap asbestos threads. The increase in strength was quite marked and is illustrated in Table V.

TABLE V.

Data:—Steam pressure, 150 lbs. per square inch. Time exposed, 10 hours.

Per Cent of Asbestos Added.	Tensile strength in lbs per sq. in.	Increase in strength in lbs. per sq. in.
3	285	7
4	297	19
5	300	22
10	343	65
12	377	100
14	302	24
20	242	36 decrease.
40	173	105 decrease.

From this table it will be observed that the increase in tensile strength rises gradually, until, when twelve per cent of asbestos is reached it drops suddenly. This shows that after twelve per cent is passed, the mixture is overburdened, and the asbestos acts as a retarder to the chemical reaction between the lime and the silica.

The effect of adding colloids was next determined by mixing into the 20 per cent lime mixture, sodium silicate, ($Na_2O\ SiO_2$), also called soluble glass, and Portland cement. Both of these substances decreased the strength of the briquets in the direct proportion in which they were added. This fact is easily seen from Tables VI and VII.

TABLE VI.

Data:—Steam pressure, 150 lbs. per square inch. Time exposed, 10 hours.

Per Cent $Na_2O\ SiO_2$ Added.	Tensile strength.	Decrease in strength.
1	189	101
2	175	105
4	114	166
5	82	198
10	50	230

TABLE VII.

Data:—Steam pressure, 150 lbs. per square inch. Time exposed, 10 hours.

Per Cent Portland Cement Added.	Tensile strength.	Decrease in strength.
2	97	183
5	93	187
10	55	125

The resultant decrease shown in Table VI is probably due, in part, to the fact that the sodium silicate was broken up by some of the dis-

solved calcium hydrate. However, in both cases the reduced strength may be explained by assuming that the grains of the mixture were kept apart by the colloidal substances.

EFFECT OF SHARP SAND.

The influence of inert substances as reviewed above suggested the use of materials which would not be of a colloidal nature. Sharp, ground, quartz, sand was added. The results are tabulated in Table VII.

TABLE VII.

Parts sand added to 100 parts standard mixture.	Tensile strength	Decrease in strength.
2	76	202
5	50	228
10	106	172
20	119	159
30	124	154
40	160	118
50	179	98
60	205	73
70	219	59
80	243	35
90	172	106
100	116	162

An inspection of the above table shows that the introduction of sharp sand decreases the total strength and, it may be added, results in a coarse porous body. For particular purposes, where such a body may be demanded, it is readily seen that eighty parts of sand yields the best results. However, in the use of this body the increase in the ratio of voids over the silica body must be considered. This would, of course, be an advantage where heat conductivity was the primary qualification, but a disadvantage with respect to weathering.[1] Slichter in discussing the origin and relations of pore-space in sands and sandstones, has shown that it depends upon the size of grains, their uniformity of size, and the manner in which they are packed.[2] Therefore, by adding the fine amorphous silica to regular sand-lime brick mixture, the expensive grinding of a part of the quartz and sand as carried out by the majority of manufacturers could be avoided. This would very materially reduce the cost. On the other hand, if a body could be used of eighty parts sand in place of the pure silica body, the cost of the product would be greatly reduced because sand is not as expensive as the amorphous silica.

[1] See bibliography, 29.
[2] See bibliography, 30.

SUPERHEATED STEAM.

The question naturally arises as to whether the chemical combination is produced by the higher temperature of steam under pressure or by the united effect of pressure and temperature. In order to investigate this question, an apparatus was arranged, consisting of a covered iron container for the briquets into which super-heated steam was introduced but which had ready egress into the air. Thermometers were placed in the steam jet and in the container for reading the temperatures. No steam pressure was used in the container. Although temperatures were used ranging from 175° centigrade up to 430° centigrade, and the time of exposure ranged from ten to forty-eight hours, no reaction could be obtained.

For this experiment new briquets were introduced into the container for each test. This was done in order to avoid the possible building up and destruction of the chemical bond, which might form. Repeated attempts to chemically combine the silica and lime by this means ended in failure. Hence, it would seem to be conclusively shown that, steam under pressure is absolutely essential to the successful bonding of lime and silica.

FIRE TESTS.

One of the main considerations taken into account when a building material is being examined is its action under fire. Accordingly fire tests were made on briquets of 20 per cent lime to 80 per cent silica in composition. These tests were made in a muffle furnace and also in a test kiln in direct contact with the fire gases. It was found that if the briquets were heated suddenly to a temperature of 800° C., which is a red heat, they cracked and burst open, at times with sufficient force to scatter the pieces a foot or so away. In these cases 800° C. was reached in twenty or thirty minutes. On the other hand, if 800° temperature was gained in from forty-five to sixty minutes, the briquets were sound and no evidence of cracking could be observed. The fact that the suddenly heated trials burst the briquets is probably due to the fact that the outer surface of the briquets were fritted before the water in the interior had time to volatilize. This explanation is more readily understood when it is considered that the chemical formula of this silicate has been shown[1] to be CaO, SiO_2, H_2O. The water, as has been said before, is chemically combined and hence does not readily break away from the other constituents, but it does detach itself at the higher temperatures. If these are quickly reached, the surface is slagged over and the water is converted to steam, which, having no ready egress, will burst the briquet. In order to determine the effect of heat on the chemical bond, trial pieces were placed in the furnace and drawn at regular temperature intervals. The heating was done over a comparatively long period of time, three hours, so that the danger from sudden heating might be avoided. The results are set forth in Table VIII.

[1] See bibliography, 33.

TABLE VIII.

Test No.	Drawn at temperature degrees C.	Tensile strength.
1	300	45
2	400	0
3	500	101
4	600	131
5	700	124
6	750	27
7	800	71
8	850	186
9	1190	260
10	1390	263

The results here recorded reveal some startling effects, for instance, at 400° C., the tensile strength drops to zero, then at 600° C. there is shown a maximum point after which there is again a sharp fall to a tensile strength of 27 pounds at 750° C. After this temperature is past, the bond is strengthened rather gradually until 1190° is reached, when it is practically at its maximum strength, for at 1390° the strength was only three pounds more. Higher temperatures than this were not attained. These results are very puzzling and although they were checked by two other similar tests, more work along this line should be done before any definite statements can be made. The peculiar action of this bond under fire might be explained by analogy. For example, in the burning of clay wares the greater percentage of mechanical water is expelled by the time 400° C. is reached, leaving the body weak and friable. At 750° the clay body begins to increase in strength until it reaches the maximum. When 750° is attained practically all of the chemically combined water is eliminated. This is also probably the case here. But just why the loss of mechanical water should allow an increase in strength while dehydration takes place is perplexing.

This analogy is, of course, faulty because clay generally contains some carbonates, sulphates, and sulphides; whereas, this lime-silica body does not, or, if it does, they are present in mere traces. The opportunity for absorption of CO_2 in the process of manufacture should be borne in mind. It is possible that the drop in the curve from 600° to 750° is due to the expulsion of the small amount of CO_2 from the carbonate which is certain to be formed in the manufacture of the briquets. This explanation is substantiated by the work of Nauss, as reported by Bleininger,[1] whose conclusions are: "That, in regard to the decomposition of calcium carbonate, it is clearly shown that it begins to break up between 610° and 650° C, and before 700° is reached the evolution of carbon dioxide is going on quite rapidly." It is very probable that the CO_2 is completely expelled from the lime-silica body by the time 750° C is reached, and that from this temperature to higher ones, the bond is free to strengthen without other interruptions.

[1] See bibliography, 31.

It is readily perceived that there are apparently two silicates formed, one between the temperatures 500° and 600° C, and the other forming at 850°, which continues up to 1,490° C. It is also seen that the compound does not entirely lose its chemical bond after 400° C is past. These apparent facts suggest the possibility that the first silicate could be formed at 600° and, without burning to higher temperatures, used as a fireproof material. This hypothesis is advanced from the fact that after 400° C is past, this material does not completely lose its combining bond. Therefore this first silicate, upon being subjected to more heat, will strengthen itself indefinitely without bloating, fusing, or cracking, to which troubles the burnt clay wares used as fireproofing are subject. Doubtless the objection to the above will be advanced by some, that the well-known volume changes of silica at 800° will occur here, causing swelling and rupture of the material.[1] This is not the case, however, since the silica is in chemical combination with the lime and it has been proven that combined silica does not undergo volume changes when heated.[1]

Some briquets composed of 20 per cent CaO, 80 per cent SiO_2, to which was added 12 per cent of asbestos were fired in a test kiln to 1390° C. The effect of heat on this body was to decrease the tensile strength by eighty pounds per square inch. The broken briquets showed that the asbestos had fused, leaving the rest of the body intact. This will account for the decrease in some measure.

CARBONATE FILLER VERSUS SILICATE BOND.

To illustrate the difference in the strength of the carbonate filler and the silicate bond, briquets were made and, without hardening by steam, were allowed to age in the air for seven months. Table IX is a table of comparative results:

TABLE IX.

Per Cent CaO.	Per Cent SiO_2	Tensile strength after hardening in steam.	Tensile strength after hardening in air.
10	90	134	97
20	80	278	189
30	70	204	155
40	60	189	121
50	50	148	101

It is to be noticed from the above that the strength is not nearly so great in the case of the carbonate filler as it is with the silicate bond. However, by aging a longer period of time it is probable that the air hardened samples would become much stronger reaching the maximum in one and a half years.

[1] See bibliography, 32.

THE EFFECT OF USING DOLOMITE AS A SUBSTITUTE FOR LIME.

To test the relative value of the silicate reaction, briquets were made of silica and dolomitic lime. The dolomitic lime was made by intimately mixing lime, CaO, and magnesia, MgO, in the ratio of one to one, which follows the mineralogical formula $\left.\begin{matrix}CaO\\MgO\end{matrix}\right\}$ —$2CO_2$. The results are recorded in Table X.

TABLE X.

Per Cent Dolomite.	Per Cent SiO_2.	Tensile strength.
10	90	116
20	80	232
30	70	168
40	60	158

In addition to the above tests, experiments were run on the effect of magnesia, MgO, and silica. See Table XI.

TABLE XI.

Per Cent MgO_2.	Per cent SiO_2.	Tensile strength.
10	90	92
20	85	186
30	80	132
40	75	124
45	70	112

It is readily seen from a study of these two tables that the magnesia reduces the tensile strength in a very marked manner. The reason for this is not clear, since MgO is almost as active as CaO in attacking SiO_2; so it can be inferred that the magnesium silicate formed is a much weaker bond than the calcium silicate.

SILICA AND ORTHOCLASE.

The suggestion was given that an attempt be made to chemically combine silica and feldspar by steam pressure. A series of tests was conducted in which the feldspar composed from 5 per cent up to 25 per cent of the total mixture. Another series was also run in which the silica formed from 5 per cent to 25 per cent of the composition. The steam pressure used was only a hundred pounds per square inch, which was all that could be obtained at that time. The tests were exposed for sixty hours to this pressure. Before putting into the autoclave, the briquets, although well dried, were apt to fall to pieces in handling. After exposure to the steam pressure they were equally fragile, showing that there had been no chemical reaction and that no bond had formed.

A SUBSTITUTE FOR CLAY-PRODUCTS.

In order to test the 20 per cent lime to 80 per cent silica mixture as a substitute for some of the clay products it was hand-pressed into a vase mold of plaster Paris. The vase dried safely and was hard enough when dried to handle and finish the joints. When hardened by steam it had, when struck with a pencil, the true hard ring of a vitrified clay biscuit. The material easily assumed and retained the shapes of the mold, hence it could be used as a terra cotta and also a stoneware body. It is not certain, at present, whether it could be cast thin enough for some of the thinner claywares or not. Small trials were also made by jiggering, which were very successful.

A great difficulty of the terra cotta and stoneware industries, which must be overcome, is the fact that, locally, the clay used, burns either red or buff. In order to glaze this with a pleasing effect, a pure white opaque enamel or "slip" is interposed between the glaze and the body. Needless to say this is a very expensive procedure, especially where tin-oxide is used as an opacifing agent. The pure white, fine-grained character of the lime-silica body will eliminate this great trouble of all the enameled clay industries. Another great point in its favor is the fact that it does not have to be burned. Stoneware is generally fired at cone 6, 1200° C, and terra cotta at cone 05, 1070° C. This, of course, represents a great expense for coal and also for kilns. Lime-silica is steamed at 150 pounds per square inch, and after the first cost of installation would require but little expense for maintenance of the hardening cylinder.

The material is strong enough and also sufficiently fire-resistant to be made into terra cotta, stoneware or enameled brick. The question as to whether it can be glazed or not was the next step in this investigation. There is no doubt[1] that it can be accomplished, since Dr. W. J. Michaelis Jr. has compounded a glaze for the regular sand-lime brick. This subject would constitute a great work by itself. It was suggested that Na_2O SiO_2 be applied as a glaze. This was done. The "water glass" when dried and hardened gave a good clear glaze but, as should be expected, was soluble in water, thus throwing it out of the field of commercial success.

CONCLUSIONS.

From the above work it is to be concluded that:

(1) The best proportions of lime and silica to gain the highest tensile strength are 20 per cent of hydrated lime to 80 per cent of amorphous silica.

(2) The best method tried, to improve the texture of the above composition is by means of molds made of plaster of Paris.

(3) The tensile strength is greatly increased by the addition of mineral fibers, which have cohesion in themselves, like asbestos fiber.

(4) The material is fire-proof[2] and can perhaps be used as a fireproofing material.[3]

(5) The effect is to decrease the tensile strength, when colloidal materials are introduced, like cement, clay, etc.

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[1] Editor's note: Ceramists state that no satisfactory glaze has yet been discovered for such purposes.
[2] See bibliography, 18.
[3] See bibliography, 9.

(6) Steam pressure is absolutely essential.

(7) The effect of using magnesia, MgO, either by itself or as dolomite, decreases the strength about one-third.

(8) Silica and feldspar will not chemically combine at 100 pounds steam pressure.

(9) The lime-silica mixture can be molded into shapes suitable for architectural decoration and also as substitutes for clay products, such as stoneware, enameled brick, and terra cotta.[1]

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[1] Editor's note: See note regarding glaze, p. 291. Silica is expensive.

PALEOBOTANICAL WORK IN ILLINOIS IN 1908.

(By David White.[1])

The following report is a preliminary statement of my paleobotanical work in the coal field of Illinois during the season of 1908. It is based on observations made in the field and on a preliminary examination of the fossil plant collections.

Six weeks of field work in Illinois were occupied chiefly with the study of the lower portion of the Coal Measures in the southern part of the State and with the task of making fossil plant collections from the main coal horizons of that region and along the northern margin of the field. As in the preceding season paleobotanical material was found to be discouragingly rare except at certain localities and very restricted horizons.

The work of the past season shows the Cheltenham fire clay, which previous tracing from Rock Island to St. Louis had located near to or directly upon the Lower Carboniferous floor in the northern part of the field, to lie at a high level in the region of early invasion of the Pennsylvanian sea in southern Illinois. In passing southward along the western margin of the coal field it appears that the edge of the deeper basin in which the earlier sediments were laid down is first met in the neighborhood of Sparta or not far south of that locality.

The continuation of the work summarized in the last year book shows the Pottsville (the lower main division of the Pennsylvanian) to extend as far north at least as Hudgins Station on the C. & E. I. R. R., though lack of exposures renders it impracticable to secure paleontological data from horizons immediately successive to the sandstone overlying the coals mined for local use at a short distance south of this point. Similarly the Pottsville is found to dip into the valley north of Bosky Dell on the main line of the Illinois Central R. R., the coals worked by Wood and others in the knob about four miles east by north of that station being probably at, or near, the base of the Allegheny formation. They may tentatively be regarded as representing the two benches of coal No. 2 at Murphysboro.

The fossil plants collected from the mines at Murphysboro, Colchester, and Minonk, and from above the "Third Vein" near LaSalle, appear, on preliminary examination, to accord so well with the flora overlying the Wilmington coal at Morris and Braidwood as essentially to confirm the generally accepted reference of these coals to the same horizon, i. e. to coal No. 2. Small collections obtained from the old mine near Bryden, in southern Illinois, from Augusta on the west, from the upper or open-air portion of the clay pit northwest of Viola, and from the lower coal at Streator, appear to belong to the flora, though the material in the in-

[1] Mr. White has spent several seasons on studies of the Illinois coal fields, being courteously detailed to the work by the Director of the U. S. Geological Survey.

dividual lots from all but the locality first named is too scanty to permit of independent correlation. As stated last year coal No. 2 is, in my judgment, to be regarded as lying very near the boundary line between the Pottsville and the Allegheny, though distinctly Allegheny in age.

Coal No. 1, as developed in the northwestern portion of the field is clearly of Pottsville age, as also is the coal mined in the deep shaft at Litchfield. The division between the two formations should, perhaps, be drawn at the horizon of the limestone which is usually found between coal No. 2, and the underlying fire clay series. The latter is apt to be surmounted by a coal ordinarily designated "No. 1," though it appears that when a thicker coal is locally developed in the midst of, or even below the clay series, this also bears the same number. In the southern part of the State this number has formerly been given to one or more coals several hundred feet below the horizon of the Cheltenham fire clays, there being several other coals in the intervening strata. The brecciated or conglomerate structure seen in the limestone at a number of points is, I believe, to be interpreted as indicating local exposures of the calcareous sediments at off-shore points, by warping, though no important change of level, or erosion, may have been experienced in this region at the time of its formation. Relative stability of level at or near the water surface for a considerable length of time may account for the comparatively narrow stratigraphic interval between coal No. 2 and the paleobotanically distinctly older sewerpipe clays with their accompanying "coal No. 1."

In this connection it may be interesting to note that the clays worked at Utica on the northern rim of the basin belong to the Cheltenham horizon and that their stratigraphic relations to coal No. 2 are nearly identical with those exhibited at East Alton, or Cantine, near St. Louis, though at Utica the fire clays repose directly either upon the St. Peter's sandstone or on residual bossses of a limestone for which a comparison with the Platteville limestone has been suggested. To the same horizon belong also the high grade sewerpipe clays used near Veedersburg, in Fountain county, and at Brazil, in Clay county, Indiana. It is thus paleobotanically shown that the most valuable sewerpipe clays worked at various points near the border of the Eastern Interior (Illinois-Indiana) coal field, extending from the Cheltenham district of St. Louis around by the north to the Brazil district of Indiana, lie practically at the same horizon and are, in part at least, contemporaneous, though the conditions of deposition appear to have been slightly different on the eastern side of the basin. Also it appears that on the Indiana side of the basin, in the vicinity of Covington, the coal described as "No. VI" in Ashley's Indiana state report for 1896, is probably equivalent to coal No. 2 of Illinois—that is to the Morris, or Wilmington, coal to which reference has already been made.

The roofs of coals Nos. 4 and 5, of the Illinois field, appear to be nearly destitute of fossil plants, particularly as to ferns preserved in such a condition as to admit of identification, marine invertebrates being nearly always present in the dark shales immediately overlying the coals. In fact it should be noted that at nearly all of the mines visited by me marine shells are found in the shales overlying the coals. This is true of

coal No. 2, as well as of the higher beds worked. The close proximity of the surface of coal formation to sea level, which is thus indicated, has an important bearing in explanation of the great horizontal extent of the individual coals in the basin, on the one hand, and, on the other, to the high percentage of sulphur in the coals of this field. At the present day, those peat bogs which have been affected by or have been subjected to salt or brackish water invasions are characterized by relatively high sulphur percentages, a feature that seems to correlate with the peculiar kind of putrefactive (bacterial) action attending such conditions of deposition.

In the region of Duquoin, Christopher, and Herrin, there would seem to have been, at the time of deposition of coal No. 6, nearby land surfaces—perhaps small irregular exposed areas—occupied by the coal forming types of vegetation. The mines in this district, which lie nearly midway across the basin, frequently show abundant fragments of fossil ferns and other delicate plant types in a condition of preservation which absolutely precludes far transportation or long suspense in water. It is probable that the old soil areas which supported this vegetation at the time of the marine submergence of the bog swamps were identical with some of the hummocks, or barren rises, which interrupt the continuity of coal No. 6 in this region.

The plants in the roof of coal No. 6 do not on closer examination appear to disclose any paleobotanical obstacle to the reference of the bed to the Freeport group, in the upper part of the Allegheny formation, with which it appears to offer a satisfactory agreement. The flora of No. 6, in southern Illinois, also agrees fairly well with that of the Grape Creek coal in the Danville region, which accordingly is, I believe, also to be referred to the same horizon. I therefore do not hesitate to refer these coals to the Allegheny formation. This reference conforms to the opinion expressed in the Danville folio, though the presence of one or two peculiar species seemed, at the time of their study, to favor a somewhat higher level. It is, in my judgment, not wholly improbable even that the Grape Creek coal may lie as low as the lower Freeport coal of the Appalachian trough.

The roof of coal No. 7 or its supposed equivalent, the Danville coal, has not as yet afforded any fossil plants in Illinois, and I am therefore unable to offer any paleobotanical evidence bearing directly on its correlation. I may, however, venture the opinion that the Grape Creek coal may be old enough to permit the inclusion of the Danville coal also within the Freeport group, and I would suggest that it be so mapped. The relatively small interval between these coals suggests a tentative reference of the Danville to the horizon of the Upper Freeport coal if the Grape Creek coal be provisionally correlated with the Lower Freeport coal as would seem to be permissible. It is interesting to note that while the horizon of No. 2 coal in this basin is marked by Ulodendron, the higher group is accompanied by frequent representatives of the *Rhytidolepis* section of *Sigillaria*.

In passing it may be remarked that the question of the validity of the distinction between coal No. 3 and coal No. 4, as presented in the earlier State reports would appear to merit critical inquiry.

PROCEEDINGS OF THE ILLINOIS FUEL CONFERENCE.

At the University of Illinois, Urbana, March 11, 12, 13, 1909.

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MINUTES OF MEETINGS.

THURSDAY, MARCH 11.

AFTERNOON SESSION, DR. W. F. M. GOSS, PRESIDING.

Formal Opening of the United States Geological Survey's Laboratory For Mine Rescue Work.

The first session of the Illinois Fuel Conference was called to order by Dean W. F. M. Goss, in the Mechanical Engineering Laboratory at 2:00 p. m. Owing to the illness of President Edmund J. James, of the University of Illinois, Dean Goss introduced to the conference Vice President T. J. Burrill, who in welcoming the members of the conference spoke as follows:

I am sorry to have to take President James' place in the performance of a function that he is better able to perform than I, and I especially regret that I am better able at this time physically than Dr. James. He is sick, and consequently unable to be with us.

The University of Illinois does not claim to give instruction in everything to everybody, for although the University has a great many departments, such a claim would be too wide. However, it does concern itself especially with many matters of real interest to the State, and so far as possible to the country at large. Since the early days there has been great growth. The time was when much attention was given to growth. The time has past when the University thinks mainly of growth. The time has arrived when the chief aim and ambition of the University is *service*. Service is the word which best describes its manifold activities.

The original construction of the I. C. Railroad was from Freeport to Cairo. When the construction of the line to Chicago was discussed, doubt was expressed as to whether the Chicago branch would ever pay. No one realized the development possible through study and coöperation in the then water soaked prairies of Illinois.

Some claim there is much ungodliness in trusts, or combinations; but there may be something not so ungodly in them. If God helps those who helps themselves, why may not the trusts come in for some assistance? Individuals operating alone cannot accomplish that which may be obtained by combined effort. Two can do more than one.

Thus, this rescue station which we are dedicating will be more useful through the effect of this and similar conferences, where, by exchange of

views, and by combination of effort, each may be aided by the experience and research of the other. On behalf of the University of Illinois we bespeak your coöperation, and extend to you a hearty welcome.

In response to Dr. Burrill, Dr. J. A. Holmes, Chief of the Technologic Branch of the U. S. Geological Survey, spoke as follows:

We are always glad to come to the University of Illinois, for several reasons. First because the University is a good place to come to, as it is a thoroughly up-to-date institution in every way. In the second place the University is always a profitable place to come for help and inspiration. On the other hand we believe that at this time we can render some service to the University through that coöperation of which Dr. Burrill has just spoken. In the past, the mining interests have been left largely to shift for themselves. It is true that many schools of mining engineering have been established throughout the country, but these have concerned themselves primarily with metal mining, leaving out of consideration the great coal mining interest. It must be admitted that the present status of coal mining is bad. Lack of coöperation makes it impossible for the coal operator to secure a fair price for his product; a price that will enable him to mine coal as it ought to be mined, with a fair degree of profit. Under present conditions in many places only 50 per cent of the coal is taken from the mine, while under proper conditions 70 per cent or more ought to be removed. Coal should be mined more efficiently, and if need be, legislation should be modified to enable this to be done.

With the coöperation of the various interests of the State it is hoped that a school of mining, particularly of coal mining, may be established here at the University of Illinois, for the purpose of developing safer and more efficient methods of coal mining. Coöperation should not be limited to one state alone. The State of Illinois should meet with help and assistance from Indiana, Kentucky, Ohio, Tennessee and other great mining states. The Rescue Station has been established here because of its favorable location, and the advantage of close connection with the Departments of Science and Engineering of the University. In the future it is hoped that other stations of like character will be established, and that the movement started here at the University of Illinois, may become a national one.

In the absence of President A. J. Moorshead of the Illinois Coal Operators Association, a letter was read from him by Dr. Bain, Director of the State Geological Survey, in which he expressed his hope that the coal operators of the State would take advantage of the opportunities offered by the establishment of the rescue station.

Mr. G. W. Traer, Past President of the Illinois Coal Operators Association, responded and addressed the Conference on Coöperation of Practical and Scientific Men.

It is a sincere pleasure to me to acknowledge, on behalf of the mine owners of Illinois, the obligations of humanity to the men whose efforts have made it possible that this great, civilized, Christian, work shall be carried on here, and whose time and thoughts are being given to it.

Illinois is to be congratulated upon the proprietorship of a University so situated that it is chosen by the federal government to participate in a work of this kind, and with a University organization qualified and eager to do so in the interests of humanity.

Special danger of injury and death never can be entirely eliminated from coal mining and many other industrial occupations. But such danger is multiplied by ignorance, indifference and lack of foresight; or it may be vastly lessened by research and application, and unreserved coöperation on the part of those whose duty it is to think and apply, with those who think and experiment. Our modern civilization is equally distinguished by a wholesome regard for lives and happiness of all human beings and by its profound scientific achievements directed towards the same end.

We are here today to witness the dedication of a work of scientific research to that end. And although we may well realize how much remains to be done, we are justified in a feeling of confidence when we reflect upon the achievements of science in the past. Seventy-two years ago Macaulay wrote his great essay on Lord Bacon, who was the prophet and the apostle of the practical sciences, as we now know them. Bacon had been dead more than two hundred years when Macaulay wrote this brilliant eulogy on the practical results of what had once been called the "new thought," and which, in advance of actual achievement, many people had considered to be merely theoretical, just as many people consider all new thoughts today. The record of the achievements of two hundred years was easily recognized by Macaulay to be without parallel in the past, when he wrote these words: "Ask a follower of Bacon what the new philosophy, as it was called in the time of Charles the Second, has effected for mankind, and his answer is ready; it has lengthened life; it has mitigated pain; it has extinguished disease; it has increased the fertility of the soil; it has furnished new arms to the soldier; it has given new securities to the mariner; it has spanned great rivers and estuaries with bridges of a form unknown to our fathers; it has guided the thunderbolt innocuously from heaven to earth; it has lighted up the night with splendor of day; it has extended the range of human vision; it has multiplied the power of the human muscles; it has accelerated motion; it has annihilated distance; it has facilitated intercourse, correspondence, all friendly offices, all dispatch of business; it has enabled man to descend into the depths of the sea, to soar into the air, to penetrate securely into the noxious recesses of the earth, to traverse the land, in cars, whirled along without horses and the ocean in ships that run ten knots an hour against the wind.

These are but a part of its fruits and of its first fruits. For it is a philosophy that never rests, which has never attained, is never perfect. Its law is progress. A point which yesterday was invisible is its goal today and will be its starting point tomorrow."

When these words were written no doubt there were many thinking people to whom this record seemed impossible of duplication, even if it did not to Macaulay.

And yet at that time the first practical steam engine had been used but little longer than the Bell telephone of today has been in practical use; the first steamboat was no older than electric lights now are; the Morse electric telegraph was as much a novelty as wireless telegraphy now is, and travel by railroad was but a few years in advance of aerial navigation of today.

Antiseptics and antitoxins were among Macaulay's invisible points and a demonstration of radio-activity would have been generally regarded as a manifestation of the evil one.

Nearly all great scientific discoveries have been made by men who dreamed and experimented, rather than by those who were working solely for practical results, but their practical application largely has been made by the latter class. Sir Humphrey Davy invented a safety lamp, but the lamp has to be carried by the man who works in the mine and who must be taught how to use it with safety. Safety helmets have been invented by men versed in scientific knowledge, but the helmets must be worn by the heroes who risk their lives for their fellowmen, and they must be trained in this use, for their own safety. The establishment of this relief station is a great humane work by men of science; but the success will depend upon the men who are to be trained in it. Only by unreserved and ungrudging coöperation of the practical and the scientific can it be hoped to secure those results which we all desire and hope to see.

For the mine owners of Illinois, I welcome and accept the proferred assistance in the discharge of our duty to humanity, and dare to hope that it may mark the beginning and be one of the important elements of a new era in the conservation of human life and happiness in the coal mines of our great State.

Mr. John H. Walker, Past President of the United Mine Workers of America, in speaking before the sixth session on the general question of mine explosions and rescue stations expressed his gratification at the experimental work under Dr. Holmes at Pittsburg, and the establishment of a Rescue Station at the University of Illinois. Though Mr. Walker was unable to be present at the opening session, his response on behalf of the miners is included here. He said in part:

The establishment of the experimental work of the U. S. Geological Survey under Dr. Holmes at Pittsburg and the rescue work here pleases me greatly. No one realizes better than the miner the dangers of his calling. One of the most frequent causes of accidents has been the fact that the composition and characteristics of explosives used was uncertain or wholly unknown. The miner buys powder purporting to be made of certain ingredients and of a certain strength. Many times its composition and characteristics are entirely different and accidents result. Our efforts up to the present time have enabled us to get the proper size of powder grain at least. Dr. Holmes' experiments at Pittsburg will give us definite knowledge about the explosives now in use.

We are at present using too much powder per ton of coal mined and this causes an increase in the number of accidents. Coal should be mined more efficiently. That 50 per cent of the coal in the mines is utterly lost beyond recall, is a fact that should rest heavily on the con-

science of any one who has any regard for future generations. At present it is not a question of the future with miners and operators; it is merely a question of dollars and cents now, and matters are settled on no other basis.

The Rescue Station here receives our hearty approval and support, for we welcome any step which leads to the prevention of accidents or relief of suffering.

At the close of the responses, letters of regret on account of unavoidable absence and of appreciation of the opportunities offered by the Rescue Station were read from T. L. Lewis, President of the United Mine Workers of America; William Green, President of the United Mine Workers of Ohio; Walton Rutledge, of the Illinois Mine Inspection Service; C. J. Norwood, State Geologist and Mine Inspector of Kentucky; W. J. Siefert, general manager of the Southern Indiana Coal Company; W. W. Williams, State Mine Inspector of Illinois; David Ross, Secretary of the State Bureau of Labor Statistics, and A. C. Lane, State Geologist of Michigan.

Dean Goss then explained briefly the objects of the Rescue Station and stated that its services would be rendered free of charge to miners and coal operators of this and other States, in coöperation with the State Geological Survey and the College of Engineering of the University of Illinois. In concluding he introduced R. Y. Williams, Mining Engineer of the U. S. Geological Survey, in charge of the rescue station work, who outlined the work of the station more in detail and exhibited and explained the working of the Draeger oxygen helmet. The meeting then adjourned to the Rescue Station and witnessed a practical demonstration of the use of the helmet in rescue work.

EVENING SESSION, MR. G. W. TRAER, PRESIDING.

The meeting was called to order at 8:00 o'clock. Mr. Traer introduced Dr. J. A. Holmes, Chief of the Technologic Branch, U. S. Geological Survey, who spoke on The Efforts of the Government to Prevent Mine Explosions. Extracts from this address will be found on page 310.

At the close of the formal address Dr. Holmes showed a few slides illustrative of the rescue station and general mining work.

Mr. Traer then introduced E. W. Parker, Statistician of the U. S. Geological Survey, who gave interesting extracts from a paper given in full on page 313, on the Coal Fields of the United States.

The last speaker of the evening was Mr. G. S. Rice, Mining Engineer, U. S. Geological Survey. His paper, entitled Work of Foreign Mining Explosion Stations, is presented on pages 317 to 326. The speaker showed various slides of the rescue stations situated in European countries which he and Dr. Holmes had visited. The same line of work will be carried on at the Urbana Rescue Station, and at other stations established in this country.

At the close of Mr. Rice's address the meeting adjourned for an informal reception held in the offices of the M. E. Department.

Friday, March 12th.

MORNING SESSION, MR. RICHARD NEWSAM, PRESIDING.

The third meeting of the conference was called to order in the chemistry building at 9:30 A. M. by Dr. H. Foster Bain, Director of the State Geological Survey. Prof. W. S. Bayley, of the Geological Department at the University, was introduced to present an illustrated lecture on "The Origin of Coal."

Dr. Bayley discussed the evidence presented by our coals; their geographic relations; composition, and fossil content. The plant remains especially indicate that the coal has been produced by bacterial decay and accompanying changes operating on buried forest beds. These lay in comparatively stagnant water at or near sea level. It is believed that certain coals, such as cannel, were formed by decay of simple one-celled plants of the Alga type; while others were derived from tree-like plants. The progressive change by loss of volatile matter from wood to peat, and to lignite, bituminous and anthracite coal was described in detail.

Dr. C. W. Balke was the next speaker to be introduced. The subject of his address was "The Chemistry of Explosives."

An explosive is a compound or mixture which is capable of rapid decomposition or combination attended by an evolution of a large quantity of gas in a more or less highly heated condition. After illustrating the nature of a compound and a mixture through the decomposition of mercuric oxide and the combination of sulphur and iron, Dr. Balke took up explosives in the order: gases, liquids, and solids. The explosion of gas mixtures was illustrated by the combination of hydrogen with oxygen, and the effect of the concentration of the oxygen on the violence of the explosion was illustrated by the explosion of hydrogen with air and with pure oxygen. Nitro glycerin was mentioned as the only liquid explosive of commercial importance. Solid explosives are either compounds or mixtures, gun cotton being an example of the former, and gun powder of the latter. The action of gun powder was illustrated by exploding various mixtures containing potassium chlorate. The explosion is explained by the fact that the potassium chlorate easily furnishes a large quantity of oxygen for the combustion of the other components of the mixture. Nitrogen iodide was used to illustrate explosions due to decomposition in the case of solids.

Following Dr. Balke's address, Dr. Bain introduced Mr. Richard Newsam, regular chairman of the third session of the conference. Mr. Newsam replied as follows:

Gentlemen—I have enjoyed Dr. Balke's address on explosives because it is a subject in which all are interested. I am pleased to be present at this conference because its purpose and the interest of the miners and operators are both for human good. It is a special pleasure to see Dr. Holmes and to note the beginning of the coöperation between the Government and the States. I am glad, too, that the Rescue Station in the middle west has been established at the University of Illinois and that the efforts of the faculty of the College of Engineering has been enlisted in its interest. It is well that we have with us Mr. Stoek of "Mines and Minerals," because of his work and travel over the whole

world in behalf of the Scranton Correspondence School of Mines. General coöperation of the public, the technical press, the scientists, the miners, the operators, the state and the government is necessary for success of this great movement. All acting together should so shape legislation that the best results from this work may be obtained. While much valuable information can be obtained in connection with mine explosives, their causes and prevention, from laboratory study and experiment, one must not forget that the laboratory and the mine are different and all the conditions prevailing in the latter cannot be reproduced in the former. I therefore most heartily approve of Dr. Holmes' intention to establish a small actual mine for experimental purposes where explosions can be studied first hand. It is desirable to extend the work of the Geological Survey in the mines and to begin at the face and strike at the real roots of the trouble, for I regret that more explosives per ton of coal are used in Illinois than elsewhere. Even under the better prevailing conditions in Illinois as to character of roof, amount of gases and the good ventilation, this practice shows its deplorable results in an increased number of fatalities in the mines. Increased use of explosives cannot be indulged in without increase of explosions and accidents. I firmly believe there is benefit to be derived from the rescue movement and hope to live to see the practical results of the present meeting.

Mr. Newsam then introduced Mr. James Taylor, State Mine Inspector of Illinois, who spoke on "Explosions." This interesting paper appears on pages 327 to 330.

The chairman next introduced Mr. James Epperson, Chief Mine Inspector of Indiana, whose remarks follow:

In Indiana, coal mine explosions arise from three causes: First, Fire-Damp; second, Explosives; third, Lack of Discipline. The third cause, of course, is closely related to the first and second. Contributory causes are: The use of fuse in shot-firing; large drill holes; inflammable tamping material; overcharged shots; and the firing of shots in too rapid succession.

We are all familiar with instances in which some miners are indifferent to the results of their actions, either to themselves or others. We have frequently seen disastrous results. On the other hand, the occasional mine in which laudable conditions prevail in handling explosives assures us that such conditions are nowhere beyond attainment.

The laws governing the size of drill holes, the amount of powder per charge, the use of fuse, of proper material with which to tamp, and the proper regulation of the firing are not and can not be entirely effective. However, such laws accomplish some good and are in the right direction. Indiana is glad of its laws limiting the size of drill holes to 2½ inches, and the maximum charge of powder to six pounds per hole, though even a smaller charge is desirable. Also, we have a law prohibiting the opening of powder cans with picks.

Following Mr. Epperson, Mr. Joan Verner, State Mine Inspector of Iowa, was introduced, and contributed to the discussion of explosions. His paper is found on pages 331 and 332.

At the close of Mr. Verner's paper, the conference adjourned to take up further discussion of the subject at the next session.

AFTERNOON SESSION, PROF. L. P. BRECKENRIDGE, PRESIDING.

On account of the lateness of the hour the morning session had adjourned without finishing the discussion of mine explosions. It was therefore decided to continue this discussion and delay the consideration of smoke prevention for a short time.

Prof. Breckenridge introduced Carl Scholz, of the Coal Valley Mining Company.

Mr. Scholz—After all of the discussion that has gone before there does not seem to be much ammunition left for me. However, there are a few things which have occurred to me that I should like to say.

Mr. Taylor in his address this morning stated that there was practically no spraying in the mines in this country today. I may say that the Coal Valley Mining Company is devoted to this practice and further that we are having no explosions or accidents.

There are three things that cause explosions: gas and dust, or both, and careless use of explosives. There are a number of conditions that must be watched, and among the most important is the humidity of the air. I know that spraying has prevented explosions in the Oklahoma mines, but what is good for Oklahoma may not be so good for Illinois. Moisture or sweat may not always prevent explosions, but it often does.

With reference to the systems of ventilation I am very much in favor of the suction fans instead of the force fans.

The manufacturers must supply a better and more uniform grade of powder, and in this connection more careful inspection must be insisted upon.

It must be recognized by this time that the mine run basis of mining coal must be done away with. This means a conflict with the miners' organization, but it must come sooner or later. A great many disasters are brought about by the abuse of this system.

Mr. Newsam—Force fans are better than exhaust fans because of the forced air currents.

Mr. Parker—Has Mr. Taylor any data on the fatalities due to the different methods of shooting coal?

Mr. Taylor—Coal reports give data on fatalities with different methods of shooting. Mines and Minerals, during the course of the year 1900 gave very complete data on this subject.

Mr. Scholz—Did Mr. Verner take readings to determine the hygrometric condition of the atmosphere or air currents in connection with the data which he reported this morning?

Mr. Verner—It was not considered of importance that these readings be taken, as the moisture determinations in my opinion are extraneous.

Mr. Stock—During the visit of Herr Meisner to this country in his numerous addresses he dwelt repeatedly upon the importance of sprinkling and the care of explosives as tending toward the prevention of explosions and accidents.

Mr. Scholz—It is my opinion that it is the alternate changes from wet to dry and vice versa that cause the damage to mine roofs.

Mr. Rice—My observation in Germany in two mines that I was permitted to visit was that there is a great deal of spraying being done. A standard temperature of 55° Fahrenheit is generally approved and this temperature has been adopted in our tests at Pittsburg as the standard mine temperature. We have made a great many careful experiments at Pittsburg bearing upon the importance of determining the hygrometric condition of the air currents and many interesting results have been obtained. However, we are not yet ready to say that our opinions are conclusive or final. We use a Schutte & Koerting aspirator for controlling our air supply. Experiments have been made in our test plant with and without coal dust and with varying degrees of moisture. It is determined beyond a doubt that the presence of moisture depresses the flame and the intensity of the explosion. With twenty pounds of dust distributed along the passageway we have noted a flame of from 40 to 60 feet in length following the explosion. There is a great deal of good to be gained from the careful study of the moisture conditions of the air currents. The effect of the moisture is clear in that the explosion must give up its heat to evaporate the moisture in the air.

Mr. Newsam—I am opposed to sprinkling a shale roof. It is impossible to maintain a constant condition of humidity.

Prof. Breckenridge—I shall ask the audience to support me in passing to the next section of our afternoon's program.

Mr. Traer opposed this move on the ground that there was great good to be gained from the discussion and that the subject should not be left half done. "Better do one thing well than two unsatisfactorily."

After some little discussion it was agreed by the vote of those present to pass to the next subject.

Smoke Suppression.

After remarks bearing upon the work of the University Experiment Station tests Prof. Breckenridge introduced Dr. W. A. Evans, commissioner of health of Chicago, who presented a very interesting paper on the subject from the physicians' point of view. The address is printed on pages 333 to 337.

At the close of Commissioner Evans' paper, Mr. Paul J. Bird, Chief Smoke Inspector of Chicago, gave a brief address, bearing upon the situation in the city of Chicago. He said, in part: "I should like to make a plea on behalf of the small steam plant. It is here that we must look for trouble in the matter of smoke suppression. There is no great trouble in the large plant, as means of solving the problem is at hand in most cases.

Illinois is a great industrial State. In 1907 the value of her manufactured product was 1,600 million dollars, more than three times the value of the agricultural products. Most of this great amount of manufactured product is made in factories and shops operated from a small steam plant of about 100 horsepower. Eighty-five per cent of the power installed in the city of Chicago where 900 of the 1,600 million dollars worth of products is manufactured is in small plants, of less than 200 boiler horse-power capacity.

In the small plants the problem of proper setting of boilers cannot be expected to receive the same consideration as in a large plant. The boilers are set just the same in Chicago for burning soft coal as in the east where hard coal is burned almost exclusively.

We are very glad to report that great strides have been made in Chicago, and for this we are indebted to Dr. Evans and a few others who have been our loyal supporters."

Prof. Breckenridge—The University stands ready and anxious to help in this work but we are handicapped by a lack of money. The manufacturing interests and the miners must help to impress the great importance of the subject upon the minds of the people.

I now have the pleasure of presenting Mr. Bement, who knows a lot more about this subject than most of us. Mr. Bement's remarks are printed on page 338.

On account of the nearness to the time when many of the delegates found it necessary to leave, Mr. Traer begged permission to submit this resolution for the consideration of the meeting:

Resolved, that it is the sense of this conference that another and similar conference be held, and that to that end the Illinois Coal Operators Association and the United Mine Workers of Illinois and the Illinois State Mine Inspectors be requested to each appoint one representative to act on a committee with a representative of the University and with Inspector Epperson of Indiana and Inspector Verner of Iowa, which committee shall arrange the time and place of the next conference.

The resolution carried.

Prof. Breckenridge presented Mr. R. H. Kuss, the Assistant Smoke Inspector of Chicago, who presented his paper on measures and methods for the suppression of smoke. He said, in part:

"The city of Chicago will never drive out Illinois coals from its limits by its smoke ordinances. On the other hand it will improve the market by making screenings and washing necessary for its use in Chicago power plants. The progress that has already been made in the efforts at smoke prevention has resulted in much greater care being exercised in the installation of new plants. The agitation has resulted in the disappearance of many fakes who hitherto frequented the market of power plant appliances. Economy in plant operation has been brought about by the scientific treatment of boiler room problems; cheaper coals have become of very general use. The problem has become so important that the field had attracted men of great engineering skill, and, as has been said before, there has been a remarkable development along the line of power plant accessories."

After these remarks the meeting adjourned.

EVENING SESSION, PROFESSOR S. W. PARR, PRESIDING.

Professor Parr introduced the first speaker of the evening, Mr. H. H. Stoek, Editor of Mines and Minerals, whose subject was "First Aid Work in the Anthracite Mines." This interesting address was accompanied by many excellent lantern slides, and unfortunately cannot be creditably printed without illustrations.

At the conclusion of Mr. Stoek's address the chairman introduced W. F. M. Goss, Dean of the College of Engineering, whose address on the "College of Engineering and the Mining Interests of the State of Illinois" is given on page 340.

At the close of Dean Goss' address, Professor Parr announced that as the time was growing late and as there were a number of speakers yet to be heard he would be glad if each speaker would confine himself as closely as consistent to the time limits of five minutes. In compliance with this request Mr. L. P. Breckenridge, Director of the Engineering Experiment Station, outlined very briefly the salient points of his address "The Work of the University of Illinois Engineering Experiment Station," stating in conclusion that he would submit to the secretary of the meeting a copy of his paper. The paper follows on page 342.

Mr. A. Bement, Consulting Engineer of Chicago, was introduced and spoke on "Smoke Suppression," as printed on page 338.

Mr. D. T. Randall, Engineer, Technologic Branch of the U. S. Geological Survey presented a useful paper on "Coals for Boiler Plants." It is printed on page 351.

Mr. R. H. Kuss, Smoke Inspector of Chicago, the next speaker introduced gave a very interesting talk the gist of which was concerned with the fact that if the consumers of coal would give more thought to coal as a means of generating steam it would afford a place for a larger per cent of saving than in any other field of activity. He was sure that many- even large consumers of coal, thought nothing of its importance; their whole attention being given to the output of the plant, be it shoes or dry goods or laundry. Such manufacturers were careful and eager to effect economy wherever possible except in their manner of burning coal, where leaks in cost, like Tennyson's brook, ran on forever. In short, he said the consumers, both large and small, should think of burning as a means of producing steam and not as a means of producing boots and shoes.

In the absence of two of the speakers of the evening Dr. Holmes requested permission to add a few words in connection with the rescue work as it would be necessary for him to leave the city immediately after the close of the session and that he would not be able to attend the sixth and final session. Dr. Holmes remarks are printed on page 359.

Following Mr. Holmes, Mr. E. H. Taylor of Chicago gave a short talk on the econmic burning of fuel in small plants. It is printed on page 361.

Mr. Carl Scholz addressing the chairman said that the suggestion of Mr. Holmes in regard to the establishment of a Department of Mines in the University of Illinois seemed to be good and in accordance with it he wished to place the following motion: The Fuel Conference now in session at the University of Illinois realizes the necessity of the establishment of a mining department in connection with the University and it is hereby resolved that a committee of nine be appointed to call upon the Legislature now in session to urge the prompt establishment of this department and the provision of the necessary funds for its operation.

That the nine committeemen be composed of three coal operators representing the Illinois Coal Operators' Association, three miners to represent the United Mine Workers' of America and three mine inspectors of Illinois.

Mr. Scholz's motion was seconded by Mr. Gordon Buchanan and the motion was unanimously adopted. Dr. Holmes moved that the selection of the committee called for by the previous motion be left to maker and seconder of the resolution. This motion was also seconded and unanimously carried.

Mr. A. Bement of Chicago moved to amend the original motion as follows: That the committee be composed of twelve members including the members above and three manufacturers to represent the Illinois Manufacturers' Association. This motion was also seconded and carried.

The meeting concluded by a short address by Mr. J. M. Snodgrass on "House Heating Furnaces." Mr. Snodgrass said briefly that the idea proposed by Mr. Taylor was the idea that gave the basis for his paper and the work that he and his assistants were doing in the Engineering Experiment Station. An outline of the paper follows on page 362.

SATURDAY, MARCH 13, MORNING SESSION, DR. U. S. GRANT, PRESIDING.

The sixth and last session of the Conference was called to order at 9:30. The Chairman introduced Dr. George Otis Smith, Director of the U. S. Geological Survey, who spoke on the U. S. Geological Survey, and the Fuel Resources of the Country. The paper will be found on pages 365 to 369.

The second speaker was Dr. H. Foster Bain who spoke on the State Geological Survey and the Fuel Interests of the State. Dr. Bain's address is printed on pages 370 to 372.

The last address of the Conference was presented by Dr. N. W. Lord, Director of the School of Mines, Ohio State University. Dr. Lord spoke on Coal Analysis. His able presentation of the subject is printed on pages 373 to 379.

At the close of Dr. Lord's address, Professor Parr made the following remarks:

I have sat too long at the feet of Professor Lord as an authority in matters pertaining to coal analysis to presume to criticize the paper. Indeed, the various points have been covered in such an excellent manner that I trust the address will be made available for reference by publication.

I wish to call attention to one point which the author has referred to but briefly, and it seems to me too modestly. This point, I think, should receive somewhat more extended remark; and that is, the matter of the constant character of the actual coal substance. It should be noted in this connection that the first reference to this fact was made by Professor Lord and Mr. Haas as a result of work done by them in 1897, and published in the Transactions of the American Institute of Mining Engineers for 1898. From the data as obtained by them up to that time

they seemed to be warranted in formulating the statement that for a given mine or a given locality the fuel value for the actual coal substance was a constant. This is a matter which is coming to have more and more significance as the matter of coal specifications and the scientific study of coal problems proceeds.

It may be worth mentioning in this connection that this conference is somewhat unique in that we have present practically all the investigators upon this special topic of the properties and heat values of the actual or pure coal substance. I may call attention to the fact that Professor Noyes, Director of this Laboratory, carried on investigations contemporaneously with that of Lord and Haas and arrived at substantially the same conclusions. The results of his work were published a few months later than those of Lord and Haas. The facts thus brought out received but little attention, and practically lay dormant until taken up by Mr. Bement, who is also present, and it is largely due to his insistence as to the value of this fact that the matter has received more practical consideration in recent years. It should also be said that Mr. E. H. Taylor of the Fuel Engineering Company of Chicago has worked along this same line from the coal inspection standpoint, and has added to its value by the data which he has assembled as well as verified in the daily routine of coal inspection. In our own investigations in this laboratory, we have also been working along the same line, and the results which we have obtained will shortly appear as a bulletin of the Engineering Experiment Station under the title of "Unit Coal and the Composition of Coal Ash." One more feature concerning the men assembled should not pass without mention, and that is the fact that a very large contribution to the data and conclusions brought to crystallization is due to the high grade of work of Mr. Summermeir of Professor Lord's Laboratory, and Mr. W. F. Wheeler in my own laboratory, who are both also present in this conference. I think these facts are worth mentioning, not only as a unique feature of this meeting, but as an historical element in the development of this point which I believe we only partially appreciate at the present time.

ADDRESSES BEFORE THE CONFERENCE.

Mining Explosions—What the Government is Doing to Prevent Them.

(By Dr. Joseph A. Holmes, Chief of the Technologic Branch, U. S. Geological Survey, Washington, D. C.)

Gentlemen—"The statement made this afternoon that coöperation is the only means of accomplishing results should be emphasized. By coöperation is meant not only that between individuals and corporations but that between governments and different branches and departments of the same government. In the past, governments were chiefly interested in the narrow interpretation of their duties laid down for them briefly in the statement that they were to protect the life and happiness of their subjects. Only within recent years have they considered it a part of their duty to protect the lives of miners against accident. Carrying out the idea of the broader function of the government different bureaus have been established and the work subdivided among different departments. Among these the comparatively new department of agriculture has set a pace beyond the capacity of the other departments to follow. It carries at the present time an appropriation of thirteen millions of dollars and has 48 experiment stations located in as many different states.

Fifty years ago the U. S. Geological Survey started the work which bears directly upon the mining interests, but only recently, that is within the last year, has it taken up the line of work bearing on the protection of miners' lives. The great conservation movement of President Roosevelt's administration includes not only the conservation of resources and property but life as well. When we consider that 75,000 persons were killed by accident last year the necessity of safeguarding human life in the rush and turmoil of the present day is apparent.

The states and the federal government must coöperate here. The federal government is now gathering and disseminating information on important subjects and this work should be done by the federal government because the burden of the work which benefits all of the states should not be borne by any single state. Furthermore, if the work should be undertaken by individual states there would necessarily be much duplication of equipment and of effort, and, consequently increased expense. There should also be coöperation with other countries to avoid international duplication of effort. There is no possible ground for conflict between the federal government and the individual interests of

the states. The government collects and disseminates information. The application of this information by intelligent inspection and supervision lies wholly within the province of the states.

At present the Technologic branch of the U. S. Geological Survey is engaged in collecting statistics in regard to mine explosions. In the early days few men were killed in mine explosions as comparatively few men were employed in that line of work. At the present time more men are employed, greater speed in mining is demanded, dust, gas and other causes contributing to explosions have increased, and consequently the number of deaths due to mine explosions have increased greatly. Preventive measures have been in general of a twofold character; first, a careful inspection of mines; second, a study of the causes of mine explosions. Past experience has shown that investigation of causes has reduced disaster more than stringent legislation in regard to mine operation. In this country on account of the growth of the coal industry and the increase in number of men employed the death rate has steadily increased.

Some idea of the rapid growth of the mining industry may be gleaned from the fact that the output of the mines from 1895 to 1905 was practically equal to the output from 1815 to 1895. It is a fact that the output of any decade has been approximately equal to the output from 1815 to the beginning of that period. Owing to this exceedingly rapid growth the mining industry is not at present an organized industry. Coal operators have been too busy for organization.

The demand for fuel has been so insistent that only the coal which could be mined easily could be mined at all. Sufficient labor has been difficult to obtain and foreign labor has been largely used. As other countries were employing their own skilled labor only the untrained and unskilled men were left for the mines of the United States. Many can speak no English and it is difficult to convey any information to them. This unskilled labor together with the increased speed of transportation and increased use of explosives makes the death rate in the United States 2½ times that in European countries. In European countries too, the price of coal f. o. b. cars at mine is $1.75 to $2.00 per ton. In America it is much lower. Consumers must pay more for their fuel in the future and learn to use it more carefully and effectively.

In the matter of explosives the government has at the present time, no effective supervision of their manufacture and use. No tests have been made as to their effect on the gases in the mine. However, at the present time stations are being established, the principal one of which is located at Pittsburgh. The following lines of work are being taken up there:

1. A test of all explosives at present on the market; the results of which are to be published later on. (In this work the Federal government does not attempt to say that a certain explosive shall or shall not be used, but merely to give the information obtained from the tests).

2. A study of the gases present in mines as to their source and liability to ignition and explosion.

3. An examination of dusts to determine their relative inflammability.

4. A study of various types of safety lamps.

5. The extent to which electricity may be safely used and the conditions under which a spark will ignite dust and thus cause an explosion.

6. A study and test of various types of rescue apparatus.

Field work is being done in the examination of localities where explosions have occurred with a view to determining the cause of the explosions. As actual mining conditions cannot always be duplicated in the laboratory, experiment stations will be established in different mines. A small mine will also be devoted exclusively to experimental work. Small educational leaflets will be issued from time to time which will be especially useful for local inspectors and fire bosses who come to take the training work at the rescue stations.

In conclusion is should be remembered that the success of all this work depends upon the active coöperation of the investigators, operators and miners, and on a sympathetic public sentiment in the creation of which the State institutions like the University of Illinois can be of the greatest assistance."

COAL FIELDS OF THE UNITED STATES.

(By Mr. E. W. Parker, Statistician, U. S. Geological Survey.)

INTRODUCTION.

According to the estimates prepared by the U. S. Geological Survey, the area underlain by workable coal beds in the United States is 496,776 square miles. Of this total area, 480 square miles contain the entire anthracite coal fields of Pennsylvania. The bituminous coal fields are estimated to be contained in an area of 250,051 square miles. The grade of coal between bituminous and lignite, and which is designated by the Geological Survey as "sub-bituminous," is estimated to be contained within areas aggregating 97,636 square miles, while the areas containing lignite aggregate 148,609 square miles.

During the last few years the Survey geologists have worked in all of these coal areas and have also been making careful estimates as to the quantity of coal contained in the beds when mining first began. In making these estimates care has been taken to ascertain how much of the supply is easily available and how much is either not available under present mining and market conditions, or is available with extreme difficulty. According to these estimates the quantity of coal contained within the known area of the United States when mining first began was 3,083,243,000,000 tons. Of this quantity a little less than two-thirds, or 1,930,018,000,000 tons, is considered as coal that is easily accessible or minable under present conditions, while slightly more than one-third, or 1,153,225,000,000 tons, is considered as non-minable under present conditions or accessible with extreme difficulty. It should be remembered, however, that the quantity of coal given above as easily accessible includes the lignites and "sub-bituminous" coals of the western states, of which approximately 530 billion tons, while easily accessible, cannot be considered available under present conditions, or those which may be anticipated in the near future. This would reduce the original supply of easily accessible and available coal to approximately 1,400,000,000,000 tons.

The first mining of coal in a commercial way in the United States was in what is known as the Richmond Basin, a small area in the eastern part of Virginia. Small quantities of coal had been mined here in the latter part of the eighteenth century and it was also in the latter part of the eighteenth and the beginning of the nineteenth centuries that efforts were being made to introduce anthracite coal for fuel purposes. The first actual records of the production of Virginia coal were in 1822,

in which it was reported that 54,000 tons were mined. In 1820 (two years before) 365 long tons of anthracite coal, or one ton for each day of the year, had been shipped to distant markets. From these small beginnings of less than a century ago the production of coal has increased until in 1907 the total output of anthracite and bituminous coal approximated half a billion tons. In 1837 the total production of the United States reached, for the first time, a total exceeding one million tons, the output being reported from four states only: Pennsylvania, Virginia, Kentucky and Illinois, although Maryland also was producing a small quantity of coal at that time. In 1840 the production amounted to a little over two million tons, the output being reported from thirteen states. Ten years later, in 1850, the production amounted to seven million tons; in 1860 it was over fourteen million tons; in 1870 over thirty-three million tons; in 1880 over seventy million tons; in 1890 it was 160 million tons; in 1900 it was nearly 270 million tons, and in 1907 it was 480 million tons. The aggregate production to the close of 1907 has amounted to 6,865,097,567 short tons.

Up to the close of 1845 the total production of coal in the United States was 27,700,000 short tons, and since that time the drain on the supply has practically doubled with each decade. The total production to 1845 and decennially since that time has been as follows:

	Short Tons.
Up to 1845	27,677,214
1846–1855	83,417,827
1856–1865	173,795,014
1866–1875	419,425,104
1876–1885	847,760,319
1886–1895	1,586,098,641
1896–1905	2,832,402,746
1906–1907	894,520,702
Total	6,865,097,567

It is estimated that for every ton of coal mined and sold, half a ton is lost or wasted, so that the total production of 6,865,097,567 short tons to the close of 1907 represents an exhaustion of 10,200,000,000 tons, or 0.3 per cent of the total original supply, or 0.7 per cent of the coal which is easily accessible and available under the present conditions. The total supply of easily accessible and now available coal left in the ground at the close of 1907 was 1,389,800,000,000 short tons.

Accompanying this statement two charts are presented, one showing the production of coal annually from 1846 to 1907, the other illustrating the average annual production by progressive ten-year periods for the same length of time, the latter chart having been prepared in order to eliminate minor variations due to abnormal conditions. The average annual increase in coal production figured from the average of progress-

ive decades shown on the second diagram is 7.36 per cent, and for the last five progressive decades—1894—1903 to 1898—1907—the rate of increase has been above that average.

DURATION OF SUPPLY.

The total reserve of easily accessible and now available coal is estimated at 1,463 billion tons. The assumption that a constant output has been reached would be utterly unwarranted. On the other hand, the adoption of the flat rate of annual increase of 7.36 per cent would involve the improbable assumption that the marvellous record of the past and present will be maintained in the future, and the production would continue to approximately double every decade. Using the waste allowance, on the basis of this constant rate of increase in production, the 1.463 billion tons available at the close of 1907 would be exhausted in 107 years, or by 2015 A. D. Against the use of the flat rate of increase it may well be contended that just as the rate of increase in population tends to diminish, so this rapid increase in per capita consumption of coal cannot persist and a constant annual production will be reached. However, the figures set fifty years ago by statisticians for the probable constant annual production of coal in England have already been exceeded by over 160 per cent.

Inasmuch as America leads the world not only in present production of coal but also apparently possesses the greatest reserve and certainly is mining coal at much lower cost than any other country, the obvious tendency will be for European countries to look more and more to the United States for their coal supply. Therefore, while our present coal production and consumption are practically equivalent, the export of coal, unless prohibited by federal legislation, must eventually become a factor and increase the coal production in the United States beyond the demands of home consumption. On the other hand, powerful influences will come to bear upon coal production, which favor lengthening the life of the supply. Thus it is to be hoped that with more improved methods in the utilization of coal the increased efficiency per unit may act as a factor in reducing coal consumption, and improved mining methods should likewise decrease the waste percentage. The increased utilization of water-power should also tend to decrease coal consumption. Again, as soon as the end appears in sight prices will rise and production diminish, and that progressively. This interference with the law of decreasing increase produced by growing scarcity will, of course, prolong the life of our coal reserves, but at the same time will greatly hamper our industries dependent on this fuel.

With so many indeterminate factors whose importance is realized but cannot be measured, prophecy must possess a questionable value.

WASTE IN COAL MINING.

The principal loss or waste attending coal-mining operations is that represented by the quantity of coal necessarily left in the ground as pillars to support the roof. In some cases it is also necessary to leave a foot or more of coal as a part of the roof, because of the unstable char-

acter of the material overlying the coal, which itself does not make a good roof. It has also been frequently the case that, where portions of the coal bed have been of inferior quality, only the high-grade coal has been mined and the poorer material left. The coal left as pillars, or as portions of the roof, may be considered a necessary loss, but that which is left because of its inferior quality cannot be considered unavoidable waste in any sense, and is frequently of higher grade than coals mined and used in other portions of the country.

Enormous quantities of coal have been lost beyond recovery from the mining of beds lying below, the caving of which, upon the withdrawal of the pillars, has so broken up the overlying strata as to render it impossible to recover the coals contained therein. This has been particularly the case in some of the coal beds of the western part of Pennsylvania, but much improvement has been observed in this regard within later years. Notwithstanding the improvement in this respect it is probable that a large amount of coal will be wasted in the western states, where a great number of coal beds are closely associated, and also where the intercalated strata are weak, forming poor roofs to the coal mines.

There are no exact figures as to the actual loss or waste sustained through coal left in the mines in conducting the mining operations, but it has been estimated that it amounts to 50 per cent of the quantity produced and marketed. In some cases, through careful mining and where the conditions are ideal for working, practically all of the contents of the coal beds are recovered. In other cases, particularly when the beds are of enormous thickness, the recovery has not exceeded 30 per cent of the contents. During the earlier days of mining in the anthracite regions of Pennsylvania it was estimated that only 40 per cent of the coal was marketed. This was partly due to uneconomical methods of mining, and partly to the large amount of coal for which there was at that time no market and which was piled on the ground in unsightly mountains. At the time of the Anthracite Coal Waste Commission, which made its report in 1893, 40 per cent was still considered a maximum recovery. So far as underground workings are concerned, there has been no revolution in the methods employed since that time, but there has been a considerable improvement in the application of those methods, which has resulted in the recovery at the present time of a materially larger proportion of the coal in the ground than was the rule at that date. The earlier methods of mining consisted in leaving comparatively narrow pillars and in the mining of large rooms, the result being that the pillars were not strong enough to stand the pressure and they were crushed beyond recovery. It is now customary to use larger pillars between the rooms, which makes it possible to better control the roof during "robbing" operations and to eventually recover a larger proportion of the contents of the bed.

The Work of the Foreign Mining Explosion Stations.

(By G. S. Rice, Mining Engineer, U. S. Geological Survey.)

The founding of the various mine explosion stations abroad did not come about until the general recognition of the important part that coal dust played in the great mine disasters. The study of safety lamps and the experiments conducted therewith in an atmosphere of fire-damp, has been carried on in various countries since the time of Sir Humphrey Davy, but these experiments and studies did not require large stations; they could be conducted in laboratories. When it began to be recognized that coal dust either accompanied by fire-damp or possibly alone would ignite from the flame of black powder and other long flame explosives, it became apparent that if explosives played so important a part in the initiation of great mine disasters, it would be necessary to conduct experiments with a view to finding out which of them would ignite coal dust and fire-damp.

In 1880 experiments on a miniature scale were conducted by the Chesterfield and Derbyshire Institute of Engineers. Their experimental gallery was 82 feet long but only 18 inches deep and 16 inches wide. This gallery was to determine, if possible, the explosibility of coal dust. A pair of horse pistols of ½-inch bore were used to represent the flame from a blown-out shot. Out of 134 individual experiments, in which the coal dust alone was tested, ignition was obtained in thirty-six of them. In forty-six experiments with dust and gas, ignition was obtained in twenty-one cases. It was reported that "in no instance—even where 6 per cent of gas was present—anything that could be termed an explosion was obtained; the only result was ignition without violence."

It is evident that the area of this gallery was too small in comparison with the surface exposed to obtain the concentration of heat necessary to sustain a rapid ignition. The terms ignition and explosion, in referring to explosive materials, are those of relative speed. As ordinarily interpreted, an explosion is extremely rapid combustion which may or may not be a "detonation," the latter indicating an almost simultaneous disruption throughout the mass of the explosive. "Ignition of coal dust" means the start of a combustion which may attain to extreme speed; if the speed is very great it becomes an explosion, and some English authorities claim that a stage of detonation may be reached.

In June, 1876, Mr. H. Hall, Inspector of Mines for the West Lancashire District, England, described, in a paper read before the North of England Institute of Mining Engineers, experiments made by Mr. Clark and himself at St. Helens in an adit 45 yards long, and which

entered the outcrop of a coal seam. Mr. Hall stated that "the flame travelled the whole length of the adit, and the blast was fierce and would certainly prove fatal to any one struck by its course."

As a result of the great explosion at the Seaham Colliery, Seaham, September 8, 1880, at the request of the home secretary, Sir Frederick Abel experimented with dust from this colliery. These experiments were made by Garswood Hall Colliery near Wigan. The Accident and Mines Commission, as the result of this experimenting, states "the proportion of fire-damp required in a mine to bring dust readily into operation as an explosive material when thickly suspended in the air, borders upon and is even sometimes below the smallest amount which can be detected in the atmosphere of a mine by the most practiced observer by the use of a Davy lamp," and, further, that "such dust particles need not be inflammable or combustible to produce the result named." In the course of the foregoing tests, a special series of experiments were made to ascertain the distances that, in the absence of dust, flame is projected from a blown-out shot. It was found that the flame when using one and one-half pounds of gunpowder, only occasionally reached a distance of twenty feet, and "even in a narrow gallery would not attain thirty-five feet."

In the opinion of the commission, these experiments afforded proof that in galleries approximating the size of the experimental gallery, coal dust in fairly dry condition will feed the flame projected by a blown-out shot.

From July to December, 1884, a series of experiments were conducted by the Prussian Fire Damp Commission at Saarbrücken. The experimental gallery was built on the surface. It was 167 feet long, elliptical in shape and had a sectional area of 17½ square feet. A side gallery, 33½ feet in length was afterwards added. A general conclusion drawn from these experiments was, that coal dust causes considerable elongation of the flame of a blown-out shot, whether there is a small amount of fire damp present or not. Their other conclusion was one that is now recognized to be wrong; namely, "in the complete absence of fire damp, the elongation or propogation of the flame is generally of limited extent, however far the deposits of dust may extend in the mine-ways." They modified this, however, by stating that "there are certain descriptions of dust which will carry the flame to distances extending beyond the confines of the dust deposits."

In 1890, Mr. Harry Hall made further experiments in a dis-used mine shaft near Ormskirk. This shaft was 50 yards deep and 7 feet in diameter. A cannon 2½ feet long with a bore of 2 inches was placed in the bottom of the shaft pointing directly upwards. The air in the shaft was then saturated with fine coal dust thrown down from the top, and the cannon fired by electricity when the dust was in suspension in the shaft. Six tests were made and in four of them, explosions were more or less violent, accompanied in three cases by a rush of flame in the air, was the result. It was especially noted that the dust which failed to ignite in one of the experiments, exploded with considerable violence when the cannon was fired two hours afterwards, no fresh dust having been added in the meantime.

A second series of experiments were made on June 26th at the Southport Pit, Haydock. The depth of this shaft was 130 yards and the diameter 18 feet. The sides were very wet and the lower part full of water. Vapor ascending from the shaft could be observed. Naturally under these conditions, no ignition of coal dust was obtained in the six attempts. A third series of experiments were tried on July 30th and October 17th and 20th, 1890, at the Big Lady Pit. This shaft was 210 yards deep and 8 feet in diameter. There were 18 experiments in all, using coal dust from different mines. In 10 cases, there was ignition of dust. In all the foregoing, experiments, black powder was used.

In Austria, from 1885 to 1890, a "Commission on Explosions" made a series of tests. In all, 353 experiments were made with 345 kinds of coal dust, generally without a mixture of fire damp. These experiments were conducted in a chamber, the explosive being a cartridge of 100 grammes of dynamite lying loose. It was found that nearly all kinds of coal dust were ignited by the explosion of dynamite; further, that a small mixture of fire-damp notably increased the danger and sensitiveness of the coal dust. The fineness of the dust as well as dryness greatly increased its sensitiveness and danger.

In England in 1892-1893, Mr. Henry Hall, at the instance of the Home Department, conducted further experiments with coal dust in a mine shaft at the White Moss Colliery, Skelsmersdale. The shaft was 50 yards deep and 7 feet in diameter. The charge was 1½ pounds of ordinary blasting gunpowder, tamped lightly with coal dust, the tamping occupied a space of 12 inches. Samples of dust from 45 different collieries were tested. Practically all of them showed ignition, often accompanied by violence.

This closes the period of somewhat primitive experimenting in connection with the use of mine explosives. The experiments at least established that most explosives used at that time were elements of great danger in a gassy or dusty mine, from the possibility of initiating a great disaster. In the light obtained by our recent investigations, fully three-fourths of the great mine disasters of the past and even the present day have been initiated by explosives.

This preliminary work led later to the establishment of the foreign government stations and the private experimental stations maintained by manufacturers of explosives.

In 1896, the English Parliament passed an Act which gave power to the Secretary of State to prohibit the use of dangerous explosives. In consequence of this, a testing station with necessary apparatus was erected at Woolrich. Quoting the words of Captain J. H. Thomson, Chief Inspector of Explosives, "Obviously it would be impossible in any test to imitate the conditions of use of an explosive in a mine; and it was considered of greater importance that the method of testing should be as uniform as possible, rather than an impracticable attempt should be made to approach actual working conditions. It was decided therefore that a mixture of coal-gas and air should be used rather than a pit-gas mixture which would be not only difficult to obtain, but would also certainly vary considerably in quality. Also a coal gas mixture is some-

what more easily ignited than one of "pit-gas and air." They considered testing with coal-dust but at that time, it was thought that uniform results could not be attained, but the controlling reason appears to have been that the gas was more easily obtained and more certainly ignitable.

"It was therefore decided that the test should consist simply of firing a given number of shots with an explosive into a highly inflammable mixture of coal-gas and air, the charges being arranged so as to be of standard strength, and being stemmed with a uniform quantity of dry clay. If the gas is once ignited during the test, the explosive is rejected."

The plant erected in 1896 has been in continuous use until the present. A large number of explosives have been tested and a considerable number of explosives have passed the test, forming what is termed a list of permitted explosives. The main feature of the Woolwich plant is the gas gallery. This is a large tube 2½ feet in diameter and 28 feet long, constructed of boiler plate. It is placed horizontally and rests on piers. It is fitted with seven safety valves along the top to relieve the strain when the gas explodes. These also serve for observation of the flame if any issues, although the observation is supplemented by a tuft of guncotten yarn placed so that an explosion of gas would ignite it. The gallery is fitted at the outer end with an arrangement for holding in place a diaphragm of paper to confine the gas. At the other end there is an iron plate with a hole in the center which is closed when the muzzle of a cannon is run up into position. Alongside of the gallery there is a gasometer fitted with a gauge also a centrifugal fan. These are connected by pipes with both ends of the gallery. The cannon is mounted on a truck for pushing into position and is 30 inches long. It has a 1⅞ inch bore.

In making a test, the cannon is loaded, run up to the gas gallery, the latter is filled with a measured quantity of gas and air at atmospheric pressure, this is circulated round and round to obtain a uniform mixture, the valve then closed to protect the fan and the cannon is fired by electric wires. When a manufacturer desires to submit a new explosive for testing and approval, if successful, the tests are conducted under these regulations:

1. The test will be carried out by H. M. Inspectors of Explosives with the testing apparatus at the Home Office Testing Station on Plumstead Marshes.

2. The charge of explosive to be fired in the test will be determined as follows:

A charge well tamped with two pounds weight of clay will be fired with the muzzle of the gun at a distance of two inches from the ballistic pendulum. From a swing registered on the sliding scale, provided for the purpose, the charge which will cause a swing of 3.20 inches will be calculated and may be verified at the discretion of the officer in charge of the Testing Station.

3. Each explosive to be subject to the following test:

(a) Ten shots with charge as determined above, and tamped with 12 inches of well rammed clay.

(b) Ten shots with three-fourths of the charge as in (a) and tamped with 9 inches of well rammed clay.

4. Every shot will be fired electrically, and in the case of high explosive a detonator of the description recommended by the manufacturer or the person submitting the explosive will be used.

5. All charges will be stemmed with dry clay well rammed.

6. Each shot will be fired in the case wrapper or covering in which it is proposed to be employed in actual use.

7. Each shot will be fired into a mixture consisting of or equivalent to 85 per cent of air and 15 per cent of the coal gas now supplied from the Royal Arsenal Gas Works.

8. An explosive will be considered to have passed the test if, in the series of twenty shots mentioned above, no single shot has ignited the gaseous mixture, or left an appreciable amount of the charge unexploded.

9. A shot may be repeated at the discretion of the officer in charge of the testing, if, in his opinion, there is reasonable ground to believe that a failure was due to any cause unconnected with the explosive."

The ballistic pendulum mentioned in these regulations is a heavy gun swinging from knife edges. A small cannon charged with the explosive shoots directly into the bore of the large cannon, causing the latter to swing. While this device does not give the force generated by an explosive in absolute terms, it gives relative values and allows the comparison of the energy of a quick explosive with that of a slow burning one.

There is also at this station a vertical gallery for testing explosives in the presence of coal dust, 4 feet 9 inches in diameter, but which is only 13 feet high. In view of the later developments in experimenting with coal dust, this vertical gallery appears entirely inadequate; however, its use at Woolwich is incidental to the testing of explosives in the presence of gas.

In Germany the first official testing station for explosives for coal mines was established subsequent to the establishment of the Woolwich station. It differs materially in design and methods of testing. The station is located at Gelsenkirchen near Cologne. It is in charge of Herr Beyling. There is a gallery 1.85 meters high, 1.40 meters wide, and 2 square meters in section, which is elliptical in shape. The length of the gallery is 30 meters. It is constructed of three layers of wood hooped with iron bands. There are large safety valves in the top and small windows with heavy glass in the sides for observing the length of flame. For testing with gas, there is an inside flange to which paper is fastened, shutting off a space of 10 cubic meters at the inner end of the gallery facing the cannon. The latter is set in a recess in a big block of concrete and simulates a drill hole in the center of the face of a mine entry. The other end of the gallery is open. The gallery lies partly imbedded in a trench for protective purposes. The observers stand in an observation room sixty feet away. The cannon is fired by an electric battery in this room. The supply of gas is obtained from a neighboring mine. It is pit-gas and largely methane. After passing through scrubbers for cleaning, it is taken into the gallery through a meter. An arrangement of

pipes and fan circulate the gas and air through that part of the gallery shut off by a paper diaphragm. A mixture of 8 per cent methane and 92 per cent air makes the most explosive fire-damp.

Besides the testing of explosives in the presence of gas, they are also tested in the presence of coal dust. In the latter tests coal dust is introduced by a funnel, into a small hole in the top of the gallery a little in front of the cannon and falls on a mechanically revolved fan which distributes the dust and keeps it mixed with the air up to the time of firing the cannon. The distinguishing feature from the English method in firing the explosive is that it is placed in the cannon loosely without tamping material.

Series of tests are made to determine the maximum amount of explosive which will ignite gas or coal dust or both. This is called the charge limit. In some respects this test is more severe than the English one. On the other hand, the English mining authorities claim that this is not a mining condition; that while it is true by accident a shot might be fired without tamping, that this is so exceptional a condition that it need not be guarded against, and on the other hand with certain explosives, it requires the tamping to develop the highest temperature so that in some cases an explosive which might pass the German tests successfully would fail with the English tests.

The work done by the German station has been of great value and has been an incentive for the invention of many new safety explosives. The manufacturers have been spurred on to erect private laboratories, some of them designing machines of the greatest value, like the Bichel machine for testing pressures developed by explosives and duration of same; also, the Bichel machine for testing the rate of detonation of explosives. While these special machines have not been employed at any of the several government stations abroad, they have been introduced at the Pittsburg Testing Station of the U. S. Geological Survey.

Explosives are also tested at the German station in another way, in Tauzl lead blocks. These are blocks of certain standard size and drilled with a hole of definite size. The explosion of a small quantity of the explosive in this block distorts it. The increase in distortion varies with the force of the explosive. These blocks are not suitable, however, for very slow acting explosives, like gunpowder.

In addition to the explosive testing apparatus, the station is provided with an apparatus for testing safety lamps in varying percentages of fire-damp and at various speeds of current; also in various directions of the current, that is, horizontal, vertical, up or down, diagonally descending and diagonally ascending. These tests are of the utmost value. Some lamps will be entirely safe in a quiet atmosphere containing fire damp, but in the air currents which traverse mine entries today, if these are heavily charged with Methane, old style lamps quickly yield. This is notably the case with the Davy lamp in a current of fire damp. For it blows through the gauze very quickly. Tests are also made of the glasses of safety lamps. Breakage of these has been in the past a fre-

quent source of danger. The effect of the tests of safety lamps have been very marked in the reduction of the number of accidents arising from the ignition of fire damp in the mines.

It is interesting to note the difference in point of view of the Germans from other nationalities regarding designs for safety lamps. They do not believe in having the lamps bonnetted, but they do advocate double gauze, although that is not yet required by law. The bonnets they admit afford better protection in very strong currents, but they oppose their use because of concealing the gauze and so make the presence of fire damp less quickly noticeable to the workman. In this respect they differ from the Belgians, French and English, who generally approve of bonnetted lamps.

The Belgium station is located at Franeries near Mons. This station is under the direction of M. Stassart, assisted by M. Bolle, both of whom are professors in the neighboring mining school at Mons and are also Government mining inspectors. The Belgian Mining Department is in charge of M. Watteyne, who, together with Herr Meissner, head of the German Mining Department, and Captain Desborough of the English Explosives department recently visited the mining districts of this country at the invitation of the United States Government. The Belgian station is located close to a group of mines and the gas used in the explosive gallery is obtained from one of the mines. The gallery was patterned after the German gallery and only differs from it in the detail of having the fans driven by motor instead of by hand. The cannon is also similarly mounted in a block of concrete at the inner end of the gallery. The bore of the cannon is 5.5 C. M. and has a length of 46 C. M. It is located at the center of the cross-section and is pointed a little upwards so that the axis projected strikes the top of the gallery nine meters from the open end. When coal dust is to be tested, it is introduced in a way similar to that at the German gallery. In some cases, dust is placed along the floor beyond the explosion division of the gallery. The disruptive force of high explosives are tested in Tauzl blocks. There is also a lamp testing gallery at this station identical with the German. In addition there is an equipment of mine rescue apparatus and a practice gallery consisting of a large square room with a glass partition, double height gallery, inclined ladders, and the usual kinds of practice material.

The French have no Government Station, but an association of the operating companies of the Pas-de-Calais district have established a station at Lievin in the central part of the district and close to a mine from which they secure the necessary fire damp for testing. M. Taffanel is in charge of this station. Some preliminary work had been done prior to 1907 in an iron gallery of small dimensions, but last year a new large gallery was erected of rectangular cross-section, about the size of a mine passage. The explosion end is constructed of reinforced concrete and the farther end of heavy timber. The general arrangement is not dissimilar to that of the German and Belgian galleries, the chief difference being in the method for introducing dust when that is used. It is distributed on the floor of the gallery. The cannon is depressed slightly

so the axis strikes the floor. The dust is not stirred into the air until raised by the concussion of the shot. Nevertheless, using plain dynamite, which is the French standard explosive for testing out coal dusts, they find all the Pas-de-Calais coal dusts will ignite and explode when fired in this way. At this station there are well equipped laboratories and a safety lamp testing gallery different in detail from the German. This is hinged to allow trial of the lamps in varying positions and with various velocities.

The explosion gallery has been erected primarily for the study of the explosibility of coal dust and the possible remedies rather than for a study of explosives. The French Government has fixed the requirements for explosives on an entirely different basis than practical tests; namely, upon the temperature developed by the combustion or detonation of the explosive. This is determined by estimating from specific heat of the component chemicals. An allowance of about 200 degrees Centigrade below the temperature which will ignite fire damp, is fixed as the limiting temperature which the explosive can develop and still be considered permissable. In other words, an explosive must not develop a temperature of over 1,500 degrees Centigrade. The other foreign authorities consider that this test is not sufficiently definite; that the actual temperatures developed may not agree with the calculated theoretical temperatures. Nevertheless, the French consider that their figures are entirely on the safe side, and in general their explosives will pass the requirements of the other stations.

I cannot better express the comparison of the different methods used abroad than to quote Captain Desborough's classification of the several methods as given in his evidence about bobinite in 1907: First, there is the theoretical or French method; second, the firing of unconfined charges, the Austrian method; third, the firing of partially confined charges as employed in Belgium and Germany; and fourth, the firing of completely confined charges as used in England.

In planning the Pittsburgh station, Dr. Holmes and his assistants have endeavored to incorporate some of the best features of the foreign stations—the gas and dust gallery is patterned somewhat after the German plan, but is larger and with additional appliances. The English method of using uniform tamping has been adopted, on the other hand, the charge limit of each explosive passing the general tests, will be determined after the Belgian and German plan. The English ballistic pendulum has been adopted to standardize the charges of explosives. The Tauzl lead blocks employed in the Belgian and German stations are also used. The safety lamp gallery is identical with those at Gelsenkirchen and Frameries. The rescue apparatus room is similar to, and somewhat larger than that at Frameries. Besides this equipment, either similar or improved over that of existing stations, the Pittsburgh plant has a large separate gallery for testing motors, lamps, etc. in fire damp and coal dust. In addition there is apparatus similar to that of certain German explosives manufacturers—the Bichel pressure testing apparatus—the Bichel rate-of-detonation apparatus used in connection with

a large covered pit in which the explosive cartridge is placed; also there is a flame photographing apparatus which has a rapidly revolving film taking successive negatives of the flames of an explosive, fired from a vertical cannon in an inclosed gallery.

A most interesting gallery for a specific purpose has recently been erected at Altofts in Yorkshire, England, by an association of mine owners and the experiments put in charge of Mr. W. E. Garforth. It is for testing the explosibility of a coal dust under varying conditions. Among other things the following points are sought for:

1. The relative explosibility of coal dust under different conditions of purity and with various air currents.

2. To see if there are such phenomona as explosion waves, and if such can be defined to find their length under varying conditions.

3. The remedy for such explosive conditions of coal dust and the trial of inert or barren zones for arresting the course of an explosion. The term inert or barren zones are areas in which coal dust has been removed or else rendered by dilution with shaly material instead of water.

The gallery is of unusually large dimensions. It is 7½ feet in diameter and about 960 feet long in all. There are a number of right angle turns in it, at which points relief doors are placed. The longest straight section is about 650 feet long. This is the explosion chamber and is also the "intake" for the air. A fan is placed at the other extremity of the gallery, and is capable of drawing 40,000 to 50,000 cubic feet of air per minute through the gallery. The latter is built of old but sound boiler shells of ⅝-inch thickness, riveted together, and the inlet end is strengthened by chain wrapped about same. The bottom is floored with concrete on which a mine track is laid. Mine timbers are also erected to further simulate a mine passageway.

In a test coal dust is laid along the bottom of the gallery and also on the timbers and lagging. A small cannon loaded with several ounces of black powder is fired electrically to stir up the dust and then as soon as the experimenter can shift the firing plug, the main cannon containing one and one-half pounds of black powder is fired. The latter is stationed about 100 feet from the mouth of the intake and pointing outward. Invariably an explosion of the coal dust is caused but of varying intensity, depending on the quantity of coal dust, the kind, the purity, etc.

At the time of the visit of the writer and Dr. J. A. Holmes the gallery was charged with coal dust for 250 feet from the inlet. The flames shot each way and came out of the inlet about 100 feet. Two days before this visit, there had been a test when a larger quantity of coal dust was used than had previously been tried. It was spread for about 400 feet along the gallery. The result was startling. Windows were blown out of houses for a mile or so around. The two end sections of the boiler plate were torn apart and pieces scattered for a quarter of a mile. We observed one piece that weighed about half a ton that had been hurled four or five hundred feet, landing not far from the bulk head erected for the protection of the shot-firer. This demonstration of the latent

power stored in coal dust, the energy displayed, increasing in greater ratio than the lineal distance traversed by the combustion was a surprise even to those familiar with mine explosions.

It is to be hoped that the experiments at the Altofts gallery with its unusual size will give the coal mining world information of unusual value about the phenomena of coal dust explosions and new and surer methods of remedy than those now known. While the use of nonflashing explosives may eliminate one of the chief starting causes, we must remember that there are other ways of originating great sweeping coal dust disasters. Small as well as large explosions of fire-damp; even bare torches, and electric arcing under exceptional circumstances; finally, fires making explosible gases.

In conclusion I venture to point out that a large, almost overwhelming series of problems confront the United States testing station at Pittsburg. We have been fortunate in having the pioneer work done by the foreign stations and our debt is very great for this and for the valuable information so freely given by the able conductors of these stations and the mining officials of England, France, Belgium and Germany.

Mine Explosions.

(By James Taylor, Representing the Mine Inspection Service of Illinois.)

Mr. President and Gentlemen—In presenting my paper to you on Explosions, I feel somewhat timid because of the educational advantages which you gentlemen have received and that have been denied to me. But a few weeks of my boyhood were spent in the school and fewer of my young manhood were spent in securing an education. The theoretical knowledge that I may have gathered along life's path has been similar to that of gathering pebbles one by one and piling them up without any idea of symmetrical construction, and in these latter days of my life I am pulling them down pebble by pebble and in so doing may throw out today one or two into your theoretical ideas of explosions and disturb the quiet brought about by your studies on this question. The thirty-four years of practical experience in the mines of this State have taught me a few lessons which I could never have learned in institutions of the State similar to this you have here in Urbana. You will find my paper thrown together somewhat, as my education has been thrown together without system or order, but such as it is I now proceed to give you.

Too much reliance is often placed by the management of our mines on the supposed security of ample ventilation. The most disastrous explosions caused by windy, or blown-out shots, in the mines of this State have occurred when the ventilation was of superior character. This is natural, as the oxygen in the good ventilating current aids in the quick ignition and combustion of the carbon monoxide gas given off by the incomplete combustion of the powder.

A windy or blown-out shot is one in which the powder blows out the tamping in the drill hole, and does not throw the coal. In such a shot the sides of the drill hole are instantly converted into small particles of coal dust and the force of the powder has been expended on the atmosphere of the mine, creating velocity, the velocity thus created puts in motion every particle of fine coal dust within the range of its force, and the carbon nonoxide gas generated by the other shots that have been fired a moment previous to the blown-out shot are exploded.

It is well known that the explosive range of a gas is the range of the percentage of that gas which is explosive when mixed with air. The explosive range of Marsh gas varies from 6 to 14½ per cent, the explosive range of carbon monoxide is much wider than this. The maximum explosive mixture of the above gas is one volume CH to 9.5 volume of air and one volume of CO to 2.4 volume of air. Carbon monoxide gas is always found after the firing of shots. This gas has a much greater power to elongate a flame than fire-damp has, on account of its wider explosive range. Most of our miners can verify the statement that they

have on several occasions returned to the working face after firing a shot, applied their lighted lamp to the smoke as it was issuing out from the coal, or between the coal and roof, from a shot that had failed to throw the coal, the result being a flame or small explosion.

The practice in a majority of the mines of this State in getting (not mining) the coal, is that of blasting off the solid, that is, drilling the blast holes horizontally into the face of the solid coal, charging them heavily with powder and tamping with find dust or clay. The evils resulting from this system of getting coal are many and great, and there is nothing to recommend it. The excessively heavy shots employed with this system of blasting coal are productive of a large proportion of the powder and coal dust being consumed in the atmosphere of the mines thus endangering the lives of the miners, also the property of the company.

I quote the following from the 1907 Coal Report of the Labor Bureau of this State:

"The number of machines increased from 962 to 1,105, nearly 15 per cent.

"The use of powder in the mines is still on the increase; this year shows that 1,261,910 kegs, twenty-five pounds each, were consumed in blasting coal; this is an increase of 234,537 kegs, or 22.83 per cent, more than was used last year.

"Seventy per cent of this powder is used in the sixth, seventh, eighth, ninth and tenth districts.

"There were 165 men killed in the mines during the year, and 636 were more or less seriously injured. The record last year was, 155 killed and 480 injured; the number injured this year is greater than for any year since 1896.

"The ratio of accidents for the year was, 2.5 killed, 9.7 injured, to each 1,000 persons employed.

TABLE 64—*Consumption of Powder in Shipping Mines—Hand Mining Exclusively, by Districts.*

Districts.	Number of tons.	Number of tons per keg.
First	1,027,342	69.94
Second	886,946	22.07
Third	1,165,497	19.92
Fourth	2,151,090	19.10
Fifth	2,663,033	22.87
Sixth	4,887,635	20.37
Seventh	2,305,908	53.51
Eighth	3,158,044	29.46
Ninth	3,480,597	26.27
Tenth	4,139,195	30.06
Totals	25,865,287	25.78

TABLE 65—*Consumption of Powder in Shipping Mines, Machine Mining Exclusively, by Districts.*

Districts.	Number of tons.	Number of tons per keg.
Third	12,945	25.81 (long wall mine)
Sixth	529,012	92.34
Seventh	4,036,737	129.34
Eighth	3,223,075	108.66
Ninth	927,209	58.69
Tenth	1,697,482	64.95
	10,426,460	96.02

During 1907, 1,338,018 tons of coal were wasted as slack and dust. Such a system of mining suggested by these figures should be condemned by all those interested in the prevention of accidents, and loss of life. Within the last few months disastrous explosions resulting in great loss of life have occurred with such frequent regularity that an investigation of the causes bringing about such accidents in our mines should be made by a commission appointed by the Legislature of this State, so that, if possible, more successful efforts may be made toward safe-guarding the lives of those employed in our coal mines.

As one who is in constant touch with the practical management of mines, I would advocate the abolition of our present system of blasting coal as the most effective preventive of mine explosions in this State, and, while I realize that it is useless at this time to advocate the return to the lump coal system of mining, nevertheless I believe this to be the surest cure for the reckless use of powder and the lack of proper preparation of shots.

Opportunity has been afforded me of investigating explosions which have occurred in mines where fire-damp had never been seen and where it has never been found since. It is universally admitted that coal dust is a "greater enemy" than fire-damp, yet it is a fact that sufficient attention is not always paid to the prevention of its production and accumulation, and, in my opinion, this can only be done by a proper system of mining and a constant and efficient cleaning of roadways. We find ample proof that it is the desire of almost every mine manager to repose comfortably under some form of watering the dust, generally the sprinkling system. Prof. Dixon, a writer, experimenter and authority on the rate of explosion in gases, has shown that if the maximum force of an explosion is to be developed, it is necessary to add 5 per cent of water vapor to mixtures of air and gas and that this volume of vapor can only be added by using steam. Therefore, it is quite clear that theoretically it is impossible to sufficiently saturate the air of a mine with water to limit the extent of an explosion. This subject has been tested in a practical way by German engineers and by actual experiment proved that very little more than 3 per cent of vapor could be added to mine air, and spraying as a protective agent was abandoned; they also proved that when certain coal dust was mixed with air, water had no restrictive action on the flame from a shot.

We have had several explosions in our mines by the lack of forethought on the part of the mine management. A violation of the mining law, which provided to enter a mine, and the lack of forethought in permitting the men to enter the mine while the fan was stopped, caused the explosion, which killed fifty men at the Zeigler Coal Company's mine April 3, 1905.

A few weeks ago twenty-eight men lost their lives in this same mine by lack of forethought on the part of the management in not making a thorough examination of all the working places in the mine with helmets before allowing the men to work therein.

Many of our explosions are clearly due to ignorance on the part of some miners, who only appear to know that powder placed in a drill hole and tamped will produce an explosion that will break the coal. They are entirely ignorant of the expansive force of powder, or of the resistance of a solid body of coal, and, in fact, of the simplest principles of mining. Instead of being miners they are, what the secretary of the Bureau of Labor calls them in his 1904 report, coal "butchers"; they are nothing more than unskilled laborers, and many of our disasters are a convincing proof of the claim so frequently made, that the successful and intelligent miner is a skilled mechanic. It is unfortunate that such unskilled labor is gaining a footing in the coal mines of our State, but the fact that this is so is before us, and a remedy is needed. What this remedy shall be is hard to say; the principle applied in other industries ought to be at least tried in the mines, and this principle is to make every man that desires a place as a miner show that he has served an apprenticeship loading coal and learned his trade before he is allowed to handle powder and prepare shots. Experience is fully demonstrating that neither life nor property is safe when in the keeping of densely ignorant and unexperienced men. The cause of explosions of all kinds should receive greater attention and consideration for the reason that no matter how intelligent, careful or circumspect a miner or a number of miners may be, they are always liable to be the victims of some foolish or overt act that would cost them their lives, and, as the strength of the weakest link in a chain measures the strength of the whole chain, so then safety is measured by the probable misconduct of some ignorant or vicious person who cannot realize the awful consequence of his misbehavior.

Too much is expected of our State inspectors of mines, and too little authority is granted to them by law. If the inspectors are to use all possible means for the prevention of accidents and to see that necessary appliances are provided for safety of those working in and about coal mines, they should receive the coöperation of the operators, superintendents, mine managers, and the miners themselves. They should have the power to discharge, and police power to arrest, those violating the law. Having such power they could compel obedience to all rules and law, and establish such discipline as to greatly lessen the danger of accident. In my opinion the majority of the explosions and other accidents may be traced to a violation of the mining law, which is the usual result of a lack of discipline.

Some Causes of Mine Explosions.

(By Mr. Joan Verner, State Mine Inspector of Iowa.)

There is not a person in this audience more pleased over the establishment of the Pittsburg experiment station than I. For a number of years I have realized the pressing need of the assistance of the national government in the investigations of mine explosions and the advisability of the creation of a central source of reliable and useful information regarding them, and I am pleased, indeed, that the help of the national government has been finally secured. I believe the work is in thoroughly competent hands, and I fully expect that the results obtained will be of material benefit to the coal mining industry of the United States.

There are two reasons why, in my judgment, we have not made more satisfactory progress in the solution of the problem of dust explosions. The first reason may be ascribed to the fact that there has been an apparent and persistent effort to befuddle the situation by dragging in non-essential, extraneous matter and by the belief expressed in some quarters that these explosions are due to mysterious agencies. We can excuse the miner for his belief in the supernatural, but it is disappointing, to say the least, to have a mining journal editorially endorse the idea that earthquakes and tidal waves may exert an influence in causing mine explosions.

The second reason is that the value of the factors entering into dust explosion and their correct relation to each other have not yet been definitely established. It is generally assumed that coal dust is the prime factor in a dust explosion. In my judgment, this assumption and belief has been largely responsible for the long continued delay in finding the proper solution of the dust explosion, for, as I see it, of the three factors entering into the problem, it is the least important. Of course, there must be an initial flame and the development of considerable heat, but aside from that the status and manner of flow of the mine air constitute the prime and determining factors in the starting of a dust explosion. To a certain extent the dust is merely a passive factor.

The air question in an explosion has been viewed so far only from the chemical standpoint, yet, important as the chemical function of air is in the explosion, its mechanical function is the deciding feature, and I shall attempt to show that mine air, under proper conditions, becomes the most effective and powerful mechanical stoker in existence.

I believe the dust is thrown into the flame by an inrush of air along the mine floor and I question the entire correctness of the claim that the flame is injected into the dust.

In an article read before the Mine Inspectors' Institute of America last June, I stated the following:

The theory that the flame of an explosion projects itself into the dust ahead of it, and thus extends the explosion's scope, appears to be extremely faulty. It suggests a sort of stationary condition of the suspended dust, or otherwise its acceptance must be based on the assumption that the explosion's flame moves faster than the dust, or, in other words, faster than its own explosive force. It would seem that argument is not required to show the apparent impossibility of this. If it is assumed that dust and flame move with about equal velocity, and that there is no inrush of air and dust, what chance will there be for the extension of the explosion, with the fuel and the air to burn it receding with a speed commensurate to that of the advancing flame? As a proof, consider Peckham's experiments; mechanical and physical properties of the air shown by Sir Frederick Abel; the dust-fired furnace.

The claim that a dust explosion's force extends from the top of the coal down to the bottom and in that condition moves in one direction only through the mine passages is unbelievable, because the force would be so tremendous as to destroy any mine, in which it was developed, beyond recovery.

As to the question of saturation, it is claimed that coal dust explosions are most frequent in the coldest months of the year, because of undersaturation. I am not prepared to say that this is not the case, but I can say that, judging from the results of the Altoft's experiments and actual explosions in this country, that neither natural or artificially produced saturation have proved reliable preventives of dust explosions in the past.

Mr. Frank Haas in his splendid paper on coal dust expresses the belief that undersaturation presents a very dangerous feature. He cites the fact that September, 1907, was a very dry month, and he estimates that during this period the return air current carried out fully 20 per cent more water than was furnished by the atmosphere in the intake, which in an ordinary mine, so he says, would represent about 3,000 gallons of water per day. Yet, under this, claimed highly dangerous condition, there were no explosions of any magnitude during the month of September, 1907, at least I have failed to hear of any. The question arises what prevented dust explosions under such circumstances, when apparently, according to Mr. Haas' view, the condition was so favorable for their occurrence. Mr. Haas favors pre-heating the air in the winter on its entrance to the mine, and, I believe, he is on the right track in this respect, and, considering that September is generally a warm month, it is somewhat surprising that he puts so much weight on undersaturation and neglects entirely the possible effect of the prevailing temperature. The work of prevention of dust explosions must commence at the working face.

Smoke Prevention.

(By Dr. W. A. Evans, Commissioner of Health, Chicago, Ill.)

I am not competent to discuss the technical side of smoke prevention in such a way as to add to your enlightenment. I will discuss smoke, therefore, as a factor in air pollution and particularly in regard to air pollution and disease.

In 1907 Chicago had 32,000 deaths. Of these 9,000 were due to what we term bad air diseases: consumption, pneumonia, bronchitis and influenza. In 1908 there were 30,000 deaths and 8,000 deaths from this group of diseases. In order that you may understand the importance of these figures, compare the 4,900 deaths from pneumonia with the 376 from typhoid; the 3,700 from tuberculosis with the 500 from diphtheria. Splitting the decennial period 1898-1907 in two and comparing the last half with the first, and, speaking in terms of deaths per 100,000 living, we find that deaths from all causes improved 26.2. A part of this was due to the following items: Improvement in acute contagious diseases, 13.2; impure water diseases, 11.7; impure food diseases, 10.8. But in the impure air diseases there is a loss of 21.7. All of the effort had been exerted on contagious disease, impure water and impure food. The related groups improved. The pollution of the air goes unchecked. The deaths resulting increase.

In 1908 war was waged on the impure air diseases. Comparing 1908 with the whole of the ten-year period just cited, and still speaking in deaths per 100,000 living, we find an improvement in the general death rate of forty-six; an improvement in the bad air disease of forty-six. Most of that was in pneumonia. The consumption improvement was slight. But the people who died of consumption in 1908 got it, in the main, in 1907 and 1906. The consumption death rate of 1909 will be a better index of etiologic conditions in 1908 than was the consumption death rate of 1908.

As you see, a little effort is doing a lot of good. Some of this effort is being put forth by the smoke commission, some by the health department, some by the manufacturers, some by the doctors, but, most of it is the effort of the people themselves.

You will note that I am talking about air pollution and bad air diseases and not specifically about smoke. Now, what are the air factors in these bad air diseases?

As I treat the subject from the disease standpoint, I must maintain my perspective, though I realize that you who work in fuel stand closer to smoke and therefore with you it looms larger than I indicate. The

most important item of air pollution is the bacterial flora thereof; the tubercle bacilli, pneumococci, diphtheria, scarlet fever and measles germs, pink eye, influenza and other bacteria of occasional interest.

I wish to make qualifying statements:

First, Pathogenesis does not persist more than a few minutes when the germs are brought in contact with sunlight and a good grade of air. Therefore not all of the germs or bacteria which get into the air are capable of spreading disease. Much of the dust is quite harmless. I rode with the First Cavalry from Chicago to Fox Lake and back last July. My usual station was at the rear of the column. There were 600 men and more horses; at times the dust made it impossible to see objects forty feet away. There were no colds. The same exposure to the infected dust of Chicago streets would have caused colds and pink eye to be nearly universal.

Second, Carriers are not of the consequence sometimes thought. The entirely well man whose mouth harbors pneumococci or diphtheria bacilli is usually doing no harm. In the process of habituation the host changes the bacillus about as much as the bacillus changes the host. The spreader is the convalescent and the man actively sick.

The second factor is trade dust. This dust is composed of fractured particles with sharp edges. The workman usually works just before a dust making machine or tool, therefore he is the point of maximum concentration. The dust of the more dangerous trades has no sulphurous acid to stifle and no odors to offend, therefore it is tolerated. For all of these reasons trade dust ranks second to bacterial flora.

In the whole population, bad air diseases cause 30 per cent of the total deaths. In metal polishers and stone cutters actively working, they cause 90 per cent of the total mortality.

The third factor is excretory air. It has been difficult to decide just what is the harmful factor in expired air. No specific poison has been demonstrated. No extraction has been accepted. CO_2 is held to be of minor consequence. Pflugge's opinion that is due to temperature acting on the peripheral nerve endings of the body is the most popular view at the present time. No one had been able to demonstrate just the poisonous agent in the other excreta. This is true of the urine and the faeces. With excretory air, urine and faeces the position is the same. The product is poisonous—efforts at further analysis have been fruitless. The opinions other than Pflugge's are moderately harmful. Pflugge's is positively harmful in that it leads entirely away from the one known fact, that the product is poisonous. It has one element of truth—cold air environment is beneficent, warm air environment is harmful. The reason is, that waste air expired into an environment of cold air, being hot, will at once rise out of the breathing zone and thereby become harmless, unless engineers, calling themselves ventilating experts, put outlets at the floor and inlets at the ceiling. Whenever the laws of men run counter to the laws of God, man suffers.

Fourth, I mention odors out of order to get the subject of the way—odors serving as warnings have helped health rather than hindered it.

The little health harm which they do, causing nausea, worry and hysteria in those who get excited about them, is offset by their efficacy in keeping people away from bad places.

Fifth, Smoke. How does smoke do harm? It fills the air with carbon particles, with CO_2, CO, SO_3 and with volatile oils. Most smoke ordinances are based on the density of smoke. I have been greatly interested in the London effort to rid their laws of the dense smoke provisions. This discussion is to be found in the Journal of the Royal Sanitary Institute for 1907. It is beginning to appear with us. For example: A few weeks ago I was visited by the agent of one skyscraper complaining of a neighboring building. Brother Bird had forced a proper firebox into the building complained of. There was no smoke. But there was a colorless gas which stifled those into whose office windows it blew.

Smoke carbon is probably as little harmful as any solid which can be taken into the human body. It is quite inert chemically. Physically it irritates but little. The harm that it does is that it transports bacteria and secure entrance for them where alone they would be repulsed. In bacteriology we have an illustration of this principle in tetanus, which affects much more uniformly in mixtures than it does alone. In physics we have the sludge filtration methods of water purification.

Sulphur compounds are very objectionable and probably more harmful. Probably before long our dense smoke ordinances will be changed so as to add to the carbon control other provisions which will control sulphur compounds. Possibly, also, combustion experiments will likewise be directed more to the solution of the sulphur problem.

Markel suggests that sulphur has something like a ferment action in the air in that in tends to be automatically renewable. He says sulphurous acid falls on iron and is at once oxidized into sulphuric acid. It corrodes the iron and makes ferrous sulphate. This picks up oxygen from the air and makes basic ferric sulphate. This picks up iron and makes ferrous sulphate and iron oxide. The rust drops off, and a new sulphur cycle is started.

Rideal found that whitewashed walls were of great service where gas was burned, as the lime took up the sulphur from the air.

Amounts of sulphur found in the air at different analyses are: London (Rideal) .015 to 0.77 grams per 100 cubic feet. The same at Manchester. At Kew an analysis of dust from an exposed surface showed 2 per cent sulphur.

Other figures for sulphur are: Cohen and Heffort say that for 100 pounds of sulphur in coal 71.78 pounds will go off as sulphur gases; 14.51 pounds will be absorbed by the soot and escape with it and 13.71 pounds will remain in the ash. In London each day 981,792 pounds of sulphur is poured into the air from coal consumption; from gas, 893 pounds; from mineral oils, 743 pounds.

In Glasgow and Manchester twenty tons of sulphur escape daily in the smoke.

Fats and oils are of increasing importance from the standpoint of air pollution. In this the automobile is a bad offender. Indirectly the oiling of the streets which has come about through the influence of the automobile has added to the proportion of oils and fats in the air.

Cohen says that in Leeds 15 per cent of the soot is mineral oil. This is less than the Chicago figures. Fats and oils probably harm health in the same indirect way as does carbon, but in a lesser measure. This may not be true of gasoline and the products of incomplete gasoline production.

CO_2 and CO: The present tendency is to believe that we can stand much higher percentages of CO_2 than are ever found in the outside air. That the devastating waves that follow volcanic eruptions are due to CO, to sulphur gases, and to other gases and not to CO_2. CO is directly toxic. CO_2 is depressent and remotely toxic and therefore for both of these reasons it is harmful. It does not kill in one whiff in any concentration. Neither does a child get a complete education in five minutes in a grammar school. Some figures are: Schafer says that London pours 100,000 tons of CO_2 into the air each day as smoke. Every ton of completely consumed coal pours about three tons of CO_2 and CO into the air.

The volume of dirt which will deposit from the air ranges from one to six tons per acre per year, according to the location, with regard to smoke and dust producers. It ranges broadly in quality. Near a boulevard it is rich in oils; near a brick kiln or a factory or locomotive yards it is rich in sulphur and in carbonic monoxide. Near an elevated road it is rich in iron.

How else does it do harm?

First, It kills vegetation. Rough equilibrium between animal and vegetable life is required to maintain atmospheric chemical equilibrium. Our two and one-quarter million people huddled on a few square miles—at places living 300 to the acre—need trees and grass. Our soil is sandy and poor; it is drained dry. It is covered by roofs and paving. Vegetation at best has a hard time. Smoke stops up its pores with carbon and with oil. The oil picks up other dirt. The SO_2 poisons when it passes one part in one million. Many kinds of vegetation will not live at all without washing, and grooming trees is expensive.

Second, It decreases sunlight. Sunlight is needed to kill bacteria and to purify the air. It adds to the cost of lighting. The St. James Gazette says that smoke costs London $73,000.00 a day for extra lighting bills. Such figures are little better than guesses. Aside from the money, these extra lights add to the harm of smoke to health.

Third, Fogs. The air heavy with suspended solids becomes surcharged with moisture and this is fog. Fogs are disease breeders.

Fourth, There are wastes aside from direct health matters which are of consequences:

(a) The loss of fuel values; the large economics of this you are engaged in working out.

(b) The laundry cost of smoke is enormous.

(c) The loss to nonwashing clothes, in stores and out, is very great.

(d) The increased painting and whitewashing expense is very great; paint is made dingy and is renewed, whitwash becomes gypsum and no longer looks white. In coal districts it is cheaper to let the weather destroy the wood than to try to protect it with paint or whitewash.

(e) Metal structures are corroded by the sulphur gases and other gases with free bonds.

(f) Wooden work is less durable as well less sightly.

(g) Property values of adjacent properties are lowered often times to a nonproductive basis.

(h) It serves to lower the general tone of a community.

A spotless town is more apt to be moral than a dirty town. It is useless to try to get a spotless town and leave the smoke. If the air is dirty it is very hard to get the streets, the yards, the clothes, the people clean.

Smoke Suppression.

(By A. Bement, Consulting Engineer, Chicago, Ill.)

The subject of smoke suppression and smokeless furnaces is one about which very much has been said and written. It has, however, in my opinion, simplified itself very much, so that all I am able to profitably say may be presented in a few words.

Every type of stoker and furnace apparatus regularly manufactured and on the market as a standard article of commerce, has produced smoke in great volume. Likewise each at times has run smokelessly, due more or less to efficient or inefficient operation and manual assistance given the combustion process, and, when manipulated with sufficient care, it has usually been possible to secure a satisfactory result. But, strictly speaking, there is no furnace apparatus on the market offered regularly for sale as a standard manufactured article which can be depended upon to burn coal without smoke. I realize that this is a rather sweeping statement; it is a fact, nevertheless. Therefore, to insure the desired result, a better type of apparatus must be employed; not at all a difficult matter, as the essentials are quite simple. The two requirements for perfect performance are as follows:

1. That coal shall be introduced to the fire at a uniform rate, which must be done automatically by machinery, such as a stoker, as introduction by hand is too uncertain and unreliable;

2. That a sufficiently large combustion chamber be afforded, so that the gases are burned before they escape.

An apparatus filling such requirements was devised in Chicago some seven or eight years ago by Mr. W. L. Abbott President of the Board of Trustees of this University, and a copy thereof is now located in the engineering laboratory, where it may be observed in operation.

The great difficulty that confronts us is that so much money is invested in the manufacture and so many people engaged in the sale of this great mass of inefficient apparatus, that improvement must necessarily be slow. These manufacturers do not want to discard their patterns and abandon the machine upon which they have built their business. In this course they are supported by their friends, among whom are consulting engineers who have specified such apparatus, and do not feel safe in taking chances with something they do not understand, notwithstanding the fact that they are credited with ability to discriminate.

The small plant, concerning which Mr. Bird has spoken, is a genuine problem. Personally, I believe that stokers are justifiable in very small

installations, very much smaller, in fact, than has usually been considered profitable. However, there is a class of service so small that it will not pay the owner to install a stoker. In such plants the presence of a man is required, and stoking the fire is a small problem. The owner would find it cheaper to engage a competent fireman who would render efficient service, than to purchase an expensive apparatus. In these cases enforcement of smoke ordinances will insure that there will be no smoke, provided a good hand-fired apparatus is employed.

The sulphur dioxide from chimneys which show no evidence of smoke as referred to by Dr. Evans, is a serious matter, and it is probable that in cities, it will be necessary to carry chimneys to a greater height than is at present the custom, so that gases may be carried up above the buildings, thus minimizing the harmful effect.

THE COLLEGE OF ENGINEERING AND THE MINING INTERESTS OF THE STATE.

Abstract of address delivered by W. F. M. Goss, Dean of the College of Engineering, University of Illinois.)

The service of first importance, which the college of engineering of the University of Illinois renders the State, is that of training young men for its industries. The extent to which this service is today being rendered by the college is to be judged by the fact that the enrollment of students during the present year exceeds 1,200. Nearly every county in the State has its representatives in the student body, and many industrial establishments of this and other states have graduates or former students of the college upon their staff. In the departments of civil, mechanical and electrical engineering are many courses which contribute directly to the different phases of the general problem involved in the production, transportation and utilization of fuels, and hence it appears that the college is already doing much of direct benefit to the fuel mining interests of the State.

In addition to its work of training students, the college of engineering stands before the industries of the State as an independent, scientific agency, prepared at all times, so far as it may be able, to give to any who may ask for it, accurate information concerning the principles of science and their application to specific industries. The developments of modern science and technology never cease, and each new fact has its effect directly or indirectly in modifying practice in the arts. Progress in one direction may open the way for movements in many different directions, and it is the province of the college to make the connection between facts, which, in themselves, may be strongly scientific or technical, and the every-day affairs of the shop and the factory. In steam engineering, in the mechanics of machinery, in the art of building, in the domains of hydraulics and materials of construction, and in the utilization of electric power, much is already being done, and more, we hope, will soon be accomplished. I believe that the presence of the faculty of the college of engineering, serving the State as an organized staff of experts representing many different fields, constitutes a possession of the industries of the State of such value as amply to justify the expense of its maintenance, even if there were not hundreds of students to receive instruction.

I regret that the College of Engineering of the University of Illinois is not yet making its contribution to the mining industries of the State complete. It is caring for the interests of civil engineering, mechanical

engineering, electrical engineering, architectural engineering, architecture, and for the various material interests of the railroad; but, as yet, it offers no courses in mining engineering and its staff does not include men who are experts in the technique of this great industry. This will not always be so. There is no fundamental reason why the college of engineering should not give the same attention to the training of mining engineers as it now gives to the training of mechanical engineers. Indeed, fundamentally there is every reason why it should give attention to the mining interests, for it stands as a representative not of selected industries, but of all the industries of a great State, and one of the greatest industries of this State is that involved in its production of coal. But the College of Engineering cannot itself dictate what it shall do. As a public institution it can but give expression to the public will. Throughout the organization of the university, those departments have been strongest for which the public has made and is making imperative demands.

The matter of securing at the University the establishment of a Department of Mining Engineering is one which rests largely with the mining interests of the State. The fact that Illinois produces annually more than 50,000,000 tons of coal and has a mineral industry amounting in value to more than $150,000,000.00 should enable the representatives of this industry to speak in no uncertain tone. There is in the State at present no center to which parties interested in mining may appear for certain kinds of scientific information, and there is no place where young men are being instructed in the problems of mining and smelting. If Illinois is to offer young men, in addition to the fundamental lines of instruction common to all engineering courses, specialized work bearing upon the location and planning of coal mines and upon problems affecting the economic production of coals and the avoidance of mine wastes, and if it is to train men effectively in problems affecting the handling, working and delivery of coal, the initial step must be taken by those most vitally interested in the outcome. The matter is one which must rest largely with the mine owner, the mine operator, the mine expert, the mine inspector, and with you, gentlemen of this conference, as representatives of these interests, I must for the present leave the matter. I shall hope that in proper time a movement may be started which ultimately will result in the establishment here at the university, under your inspiration, of an organization of men who know the problems of the mine. I feel sure that a department thus directed and inspired would have an important part in promoting economy and increased efficiency in the process of mining, and would ultimately prove helpful to every interest of the State.

The Engineering Experiment Station of the University of Illinois.

(By L. P. Breckenridge, Director.)

DATE OF ORGANIZATION.

The Engineering Experiment Station of the University of Illinois was established by action of the board of trustees, December 8, 1903, in connection with the College of Engineering.

There were two influences which led to its establishment; first, a continual demand from the industrial interests of the State for scientific experimentation relating to manufacturing processes, fuel economies and transportation problems; secondly, the very great success attending the work of the Agricultural Experiment Station at the University, which made it evident that a similarly successful career ought to be possible for an Engineering Experiment Station. It is very evident from the work which has now been accomplished by the station, and the many helpful things it has done for the industries of the State, that no mistake was made in establishing such a station.

ORGANIZATION.

The control of the Engineering Experiment Station is vested in the heads of the several departments of the College of Engineering. These constitute the station staff, and, with the Director, determine the character of the investigations to be undertaken. The investigations are carried on by the members of the staff directly, by fellows as graduate work, by members of the instructional force of the college, and by special investigators belonging to the station corps.

PLAN AND SCOPE.

It is the purpose of the station to carry on investigations along various lines of engineering, and to make studies of problems of importance to professional engineers, and to the manufacturing, mining, railway, constructional and industrial interests of the State. It is believed that this experimental work will result in contributions of value to engineering science and to the industries of the State and that the pursuit of such investigations will give inspiration to students and add to the value of the instructional work in the College of Engineering.

REPORTS PUBLISHED.

The results of the investigations made are published in the form of bulletins, which record mostly the experiments of the station's own staff of investigators. There are also issued, from time to time, circulars and compilations giving the results of the experiments of engineers, industrial works, technical institutions and governmental testing departments. The bulletins of the station are distributed among the engineers and manufacturing interests of the State of Illinois, to libraries and the technical press of the country and to such special organizations as are particularly interested in the subject-matter discussed by individual bulletins. Already there have been published twenty-five of these bulletins and from five to twenty thousand copies of each one have been distributed.

FUNDS ANNUALLY AVAILABLE.

In carrying on the activities of the Engineering Experiment Station, there is necessary a large amount of equipment of various kinds suitable for investigational purposes. The regular equipment provided for instruction in the College of Engineering has always been used for these investigations, supplemented by the purchase of special apparatus necessary for special researches in the Engineering Experiment Station. After an investigation has been concluded, this apparatus becomes a part of the equipment of the department to which it most naturally belongs. The item of expense for equipment, therefore, does not enter into the general expenses of the Engineering Experiment Station. (The value of this total equipment in the College of Engineering is now about $225,000.00.)

The funds expended in carrying on the investigations, already completed and now in progress, have been during the last five years a little over $100,000.00, making an annual expenditure of about $30,000.00.

The existence of the Engineering Experiment Station at the University of Illinois makes it possible to utilize:

(1) The library facilities of the university.

(2) The continual extension of the equipment of the various departments of the College of Engineering.

(3) The helpful suggestions and coöperation of other scientific departments at the University outside of the College of Engineering.

With these three aids the expenditure of our funds is bound to result in much larger returns than would be possible otherwise.

SUGGESTIONS FOR FUTURE WORK.

In determining the character of the work which the station shall undertake, the most careful consideration will be given first to the needs and the interests of the State of Illinois. Fortunately, Illinois is singularly favored in all the conditions requisite for a rapid and permanent industrial development, and its interests cover very wide fields of engineering activity. In view of its cheap and abundant fuel, its great

agricultural wealth and its unexcelled facilities for the transportation of raw material and finished products, it is not surprising that Illinois is the second state in the Union in agriculture and third in manufactures. With these great resources devolves upon us great responsibility in developing and husbanding them. The testing of its materials of construction will always be a matter of importance for any state. The prevention of the waste of material growing more and more expensive, as wood, and the correct factors of strength of new materials, as concrete, are always subjects for the most careful investigation. To this work we are giving considerable attention, and the demand for the results of our tests on reïnforced concrete, which are being carried on under the supervision of Prof. A. N. Talbot, indicates the interest which is taken in this work and the necessity felt by architects, constructors and builders for the most exact information along these lines.

The work of the station will also extend into some fresh fields, seeking to discover new ways and means for economizing energy and materials, for the prevention of waste, for the perfection of labor-saving machinery, for safer methods of travel, and for surer sanitary methods of water supply and sewage disposal.

Fuel supply is of such prime importance in our industrial development that no effect will be spared in the introduction and promulgation of improved methods and processes in the mining, preparation and consumption of coal. From broad economical considerations wasteful methods of using coal, or the rejection of any combustible part as waste, are to be discountenanced. Exhaustive and careful experiments will be required before the best conditions can be attained. These experiments must include analyses of coals from all parts of the State, a determination of the best kinds of coal for specific purposes, best methods of burning Illinois coals, effects of various methods of preparations, experiments on various kinds of furnace construction, etc.

Along the line of power production there is opportunity for much investigation. New problems are confronting both the builders and users of steam and gas motors. There is at present a noteworthy change from the reciprocating engine of large size to the steam turbine. Gas engines of large power have recently been installed, and the development of this type of motor bids fair to be more rapid in the near future. Still newer types of motors are being proposed from time to time, the gas turbine being one that at present occupies much attention as an attractive possibility.

For the user of power, the station can investigate questions relative to the economy of various types of power installations with given conditions of service. For the builders of motors it can investigate the new and perplexing problems that have arisen. The properties of the various fluids used in heat motors need careful study. Superheated steam is essential to the proper working of a steam turbine, yet many of its properties remain to be investigated. The properties of ammonia and other fluids used in refrigeration are not known accurately, and even the properties of saturated steam are based on Regnault's experiments made nearly seventy years ago. A careful investigation of the properties of

heat media of all kinds, extending, if necessary, over a series of years, would furnish data of the greatest value to engineers, and would in addition be a noteworthy contribution to science.

Considerable work for the railroad interests has already been done by the Railway Engineering Department of the University. This department owns jointly with the Illinois Central Railroad a dynamometer car equipped for steam road experimental work. With this car there have been made numerous road tests for the establishment of tonnage ratings. The department also owns a 200-horsepower electric car of the interurban type, especially designed and thoroughly equipped for electric traction work. Railway work with both these cars will be prosecuted vigorously under the direction of the new school of railway engineering and administration recently organized.

It is expected that the experiment station will prove helpful to the manufacturing and building interests. In the first place, it will supply accurate data regarding the properties of the materials used in engineering structures and buildings. The laboratory of applied mechanics with its extensive field needs much greater facilities for this line of work, as the reïnforced concrete tests now in progress show great possibilities. In the near future, an extensive series of tests on cast-iron columns, and on various forms of steel and iron members is contemplated. Secondly, the experiment station will investigate manufacturing processes. As an example of this line of work the high-speed steel tests are cited. Thirdly, problems relating to design and construction will be studied, and all useful results will be published for the benefit of those engaged in design or construction.

As a rule the experiment station will undertake only such investigations as will lead to results of fundamental importance, results that will be helpful to a large class of engineers or manufacturers. It will not, in general, undertake work of importance to individuals only, e. g., the testing of a device or invention for the sole benefit of the inventor.

The station is now planning to make a more systematic study of the industrial and engineering interests of the State of Illinois, more particularly with the thought in mind that these industries should be advised as to the work already accomplished by the station, and also that more exact knowledge may be obtained concerning the needs of the various industrial interests throughout the State. Kenneth G. Smith, Assistant Professor of Mechanical Engineering, has been appointed in charge of this work.

Prof. Smith, in the capacity of Industrial Visitor, will visit the manufacturing centers of Illinois in order to become acquainted with the problems confronting these various interests, so that such fundamental problems as affect a large number of our industries can be taken up and such study of these problems made as facilities and funds permit.

SUGGESTIONS FOR FUTURE WORK.

1. (a) The determination of the strength of materials used in constructive engineering work.

(b) A study of municipal water supply and sewage disposal as affecting public health.

2. FUEL INVESTIGATIONS.

(a) A study of the best methods of using economically the fuels of the State, not only for the production of power, but for the heating of buildings, metallurgical purposes, etc.

(b) Economic production and use of steam.

(c) Use of Illinois coal in the gas-producer and gas engine.

(d) Utilization of oil products for economical and industrial purposes.

(e) A study of the development and economical use of the machinery used in mining operations.

(f) A study of the development and economic production of manufactured products.

3. (a) A study of the economic construction and maintenance of roads.

(b) A study of the properties and strength of fabricated articles, such as bridges and frame work of important engineering machines and structures.

4. (a) Generation, transmission and utilization of electrical energy.

(b) A study and investigation of the economic and satisfactory methods of telephony.

5. A study of the problems of economic transportation of materials by rail and water.

PUBLICATIONS OF THE ENGINEERING EXPERIMENT STATION.

The demand for our publications has, in some cases, entirely exhausted the supply. We regret, therefore, that we cannot comply with your request. The following list shows which of the bulletins are still available. We shall be glad to mail any of these to you upon request.

BULLETINS OUT OF PRINT.

Bulletin No. 1. Tests of Reinforced Concrete Beams, by Arthur N. Talbot. 1904.

Circular No. 2. Drainage of Earth Roads, by Ira O. Baker. 1906.

Bulletin No. 3. The Engineering Experiment Station of the University of Illinois, by L. P. Breckenridge. 1906.

Bulletin No. 5. Resistance of Tubes to Collapse, by Albert P. Carman. 1906.

Bulletin No. 6. Holding Power of Railroad Spikes, by Roy I. Webber. 1906.

Bulletin No. 8. Tests of Concrete: I. Shear; II. Bond, by Arthur N. Talbot. 1906.

Bulletin No. 10. Tests of Concrete and Reinforced Concrete Columns, Series of 1906, by Arthur N. Talbot. 1907.

Bulletin No. 11. The Effect of Scale on the Transmission of Heat through Locomotive Boiler Tubes, by Edward C. Schmidt and John M. Snodgrass. 1907.

Bulletin No. 12. Tests of Reinforced Concrete T-beams, Series of 1906, by Arthur N. Talbot. 1907.

Bulletin No. 14. Tests of Reinforced Concrete Beams, Series of 1906, by Arthur N. Talbot. 1907.

Bulletin No. 17. The Weathering of Coal, by S. W. Parr, N. D. Hamilton and W. F. Wheeler. 1908.

BULLETINS AVAILABLE.

Circular No. 1. High Speed Tool Steels, by L. P. Breckenridge. 1905.

Bulletin No. 2. Tests of High Speed Tool Steels on Cast Iron, by L. P. Breckenridge and Henry B. Dirks. 1905.

Bulletin No. 4. Tests of Reinforced Concrete Beams, Series of 1905, by Arthur N. Talbot. 1906.

Bulletin No. 7. Fuel Tests with Illinois Coals, by L. P. Breckenridge, S. W. Parr and Henry B. Dirks. 1906.

Bulletin No. 9. An Extension of the Dewey Decimal System of Classification Applied to the Engineering Industries, by L. P. Breckenridge and G. A. Goodenough. 1906.

Bulletin No. 13. An Extension of the Dewey Decimal System of Classification Applied to Architecture and Building, by N. Clifford Ricker. 1907.

Bulletin No. 15. How to Burn Illinois Coal without Smoke, by L. P. Breckenridge. 1908.

Bulletin No. 16. A Study of Roof Trusses, by N. Clifford Ricker. 1908.

Bulletin No. 18. The Strength of Chain Links, by G. A. Goodenough and L. E. Moore. 1908.

Bulletin No. 19. Comparative Tests of Carbon, Metalized Carbon and Tantalum Filament Lamps, by T. H. Amrine. 1908.

Bulletin No. 20. Tests of Concrete and Reinforced Concrete Columns, Series of 1907, by Arthur N. Talbot. 1908.

Bulletin No. 21. Tests of a Liquid Air Plant, by C. S. Hudson and C. M. Garland. 1908.

Bulletin No. 22. Tests of Cast-Iron and Reinforced Concrete Culvert Pipe, by Arthur N. Talbot. 1908.

Bulletin No. 23. Voids, Settlement and Weight of Crushed Stone, by Ira O. Baker. 1908.

Bulletin No. 24. The Modification of Illinois Coal by Low Temperature Distillation, by S. W. Parr and C. K. Francis. 1908.

Bulletin No. 25. Lighting Country Homes by Private Electric Plants, by T. H. Amrine. 1908.

Bulletin No. 26. High Steam Pressures in Locomotive Service, by W. F. M. Goss. 1909.

Bulletin No. 27. Test of Brick and Terra Cotta Block Columns, by Arthur N. Talbot. 1909. (In press.)

Bulletin No. 28. A Test of Three Large Reinforced Concrete Beams, by Arthur N. Talbot. 1909. (In press.)

Address all requests and changes of addresses to the Director, Engineering Experiment Station, Urbana, Illinois.

LINES OF INVESTIGATION IN PROGRESS MARCH 1, 1909.

I. ARCHITECTURE.

1. Study of plain base and bearing plates for columns ......N. C. Ricker
2. Study of ribbed base plates for columns .... C. E. Noerenberg
3. Economical design of steel roof trusses .... C. E. Noerenberg
4. Economical design of wooden roof trusses ....N. W. Overstreet
5. Description of specialties and conveniences adapted for isolated country dwellings .... J. M. White

II. CIVIL ENGINEERING.

6. Tests on the action of rolling loads on ordinary highway bridges .... J. P. Brooks, F. O. Dufour
7. Standardization of the rattler test for paving brick ......L. G. Parker
8. Use of concrete on the farm .... J. J. Richey

III. ELECTICAL ENGINEERING.

9. Tests on tungsten lamps .... T. H. Amrine
10. Interference between high potential and telephone lines ......A. Guell
11. Tests of household electric appliances .... W. C. Maddox
12. Experiments upon the utility and limitations in the use of electric andirons .... W. C. Maddox
13. Electric drives for machine tools ....J. M. Bryant
14. Investigation of the clays of Illinois with a view to the possibility of the manufacture of insulators for high potential lines.J. M. Bryant

IV. Mechanical Engineering.

(a) general.

15. The flow of steam through nozzles.....G. A. Goodenough, K. G. Smith
16. Transmission of heat through tubes under varying velocities of water flow .... C. M. Garland
17. Tests on constant pressure generator ....C. M. Garland
18. Gas producer tests at varying capacities .... A. P. Kratz
19. Explosive mixtures of gases or the study of premature ignition in internal combustion engines .... R. E. Robinson
20. Problems in steam heating by central station system ....W. D. Scott
21. The cost of power .... J. C. Thorpe

(b) fuel.

22. Fuel tests with house-heating boilers.....J. M. Snodgrass, F. L. Busey
23. Experiments on a smokeless furnace .... J. M. Snodgrass
24. Fuel tests with hot air furnaces .... J. M. Snodgrass
25. Fuel tests with Illinois coal in power plant boilers .... C. S. McGovney
26. The weathering of coal ....W. F. Wheeler
27. Causes which promote the spontaneous combustion of coal.W. F. Wheeler
28. Tests of Illinois coals by U. S. G. S. .... Paul Diserens
29. Occluded gases in coal .... F. W. Bliss
30. The low temperature distillation of coal .... E. C. Hull

V. Miscellaneous.

31. The thermo-conductivities at high temperatures ....W. L. Egy
32. Boiler waters .... J. M. Lindgren

VI. Railway Engineering.

33. Electric car resistance ....E. I. Wenger
34. Boiler plate temperatures .... A. S. Williamson
35. Wheel flange pressures .... A. S. Williamson, F. W. Marquis
36. Economic spacing of railroad ties ....S. S. Roberts
37. Tests of rock ballast road-bed .... S. S. Roberts
38. Resistance of interurban cars on curves .... D. C. Faber
39. Train resistance tests on steam roads ....F. W. Marquis
40. Relation of economic conditions of territory to types of electric roads .... E. V. Camp.

VII. Strength of Material.

(a) reinforced concrete.

41. The properties of reinforced concrete columns with special reference to the use of large amounts of steel .... A. N. Talbot
42. The properties of reinforced concrete beams; web resistance and modulus of elasticity .... A. N. Talbot
43. Reinforced concrete wall footings and pier footings ....A. N. Talbot
44. An investigation of continuous beams made with reinforced concrete ....D. A. Abrams, J. H. Nelson
45. Bond between concrete and steel .... D. A. Abrams

(b) strength of materials.

46. The distribution of stress in structural steel columns .....A. N. Talbot
47. A study of tests of timber stringers ....A. N. Talbot
48. The distribution of stresses in structural steel compression pieces .... H. F. Moore
49. The action of metals under torsional and under combined flexure and torsion ....H. F. Moore

50. An investigation of tie plates ....H. F. Moore
51. Resilience of metals beyond the elastic limit ....H. E. Murdock
52. Strength and cost of acetylene oxygen welds in steel and other metals ....H. L. Whittemore

(c) HYDRAULIC.

53. Flow of water through sand and well screens ....R. H. Slocum
54. The discharge of water from orifices and short tubes ...W. R. Robinson
55. An investigation of water hammer in pipes ....M. L. Enger
56. Measurement of water by means of vertical tubes ....M. L. Enger

Economy in the Use of Fuel.

(By A. Bement, Consulting Engineer, Chicago, Ill.)

There are many features concerning the economical use of coal, such as that of securing combustion with high CO_2 and small air supply; utilization of the heat by efficient boilers, and many other items of like character to which I shall not refer.

There are two things, however, not very well understood, that to my mind are of special moment, the importance of which have been underestimated. One is the loss in smoke when coal is improperly burned, which, it would appear, is equal to about 10 per cent if the fuel used is bituminous coal and the furnace an average smoke producer. The other feature is the loss of efficiency caused by excessive ash in coal, or, in other words, fuel having dirt mined or mixed with it. Such coal burned in a calorimeter generates a full measure of the heat content therein. When used in a commercial fire, however, the percentage of heat realized therefrom decreases at a remarkable rate with increase in ash. In this connection the Journal of the Western Society of Engineers, Vol. XI, p. 530, contains a paper by Mr. W. L. Abbott, presenting results of experiments, wherein a uniform size of coal was employed in a series of tests with a boiler and chain grate stoker. On the first day of the experiments the coal was burned in the condition as received. On the second day a small quantity of ash was thoroughly mixed with the coal, and on each succeeding day an increased quantity of ash added, until a point was reached where no steam was generated at all, which condition developed when the per cent of ash in the dry coal was 40, or, in other words, 60 per cent of the dry coal was burned up without producing any useful effect.

In the conservation of our natural resources, these two facts, so far as I am aware, have not been considered. That they are of enormous importance, however, may be readily realized, if these two losses, one from smoke and the other from decreased efficiency due to dirt in coal, be calculated upon a basis of the total coal production of the State.

These two conditions are caused, first, by improperly constructed furnaces; second, by careless mining methods. One of the things that is conducive to dust explosions in mines, that of blasting from the solid face, is responsible for dirty coal, and dirty coal is not only a damage to the business of the coal producer, but likewise an injury to the consumer.

Coals for Boiler Plants.

(By D. T. Randall, Engineer, U. S. Geological Survey, Washington, D. C.)

INTRODUCTION.

It is well known that certain coals are especially suited for locomotive use, others for metallurgical use, for illuminating gas, or for the manufacture of coke, etc., but all coals are considered as a possible fuel for boiler plants.

This being so, it is important to know about the design of furnaces and the influence of certain characteristics of coal in order that the best results may be obtained.

FURNACES.

An ideal furnace would, of course, be one in which all coals, no matter what the character of their composition, could be burned with equal efficiency.

Kinds of Furnaces.—Furnaces may be generally classified as follows:

1. The hand fired grate set in a chamber enclosed by the iron surfaces of the boiler, as in the internally fired boilers of marine type, in the locomotive type used for stationary purposes, house boilers and small vertical boilers. These boilers cool the gases from the coal and are not suited for use with coals containing more than a small percentage of volatile matter. Where bituminous coal is burned in such boilers there is a considerable loss of unburned gases, as is evidenced by the smoke given off.

2. Hand fired grates set in a chamber partially enclosed by brick and with the boiler surfaces just above or near the surface of the fire. This includes the usual setting for horizontal return tubular and water tube boilers. These are not suited for burning bituminous coal.

3. Hand fired grates set in a brick chamber with a considerable space for combustion to take place before the gases reach the surfaces of the boiler. This may be accomplished by brick arches, tiles, etc., and, in addition, piers, baffle walls and other devices are added to assist in mixing the gases and air while within the combustion space. With these may be included down draft furnaces, and coking furnaces fired by hand.

Many of the above when carefully fired give good results and, with certain sizes and kinds of coal, they may be operated without dense black smoke, but usually not without some smoke. Often a special coal is required to secure good results. This creates a demand for coals low in ash and of large size. Screenings are seldom burned on such furnaces with good results.

4. Automatic stokers partially enclosed in brick with a small combustion chamber and a short distance from the grates to the boiler furnace. Such settings usually give good results except at high capacities or when the load is changed suddenly. They give off more or less smoke depending upon the size and character of coal used. Coals high in fixed carbon may be used with good results.

5. Automatic stokers enclosed in brick settings with a large combustion chamber and a considerable distance from the grates to the boiler surfaces. Such settings will burn almost any size or kind of coal with economy and without smoke within reasonable ranges of load.

Time is required for the air and gases to burn and any means that will facilitate the ultimate mixture of the air and gases will reduce the size of the combustion chamber necessary for good results. In general then, for most coals, and especially for those which have high percentage of volatile matter, it has been found more satisfactory to install some kind of device which will feed the coal regularly in small quantities, allowing it to become heated gradually, driving off a practically uniform amount of gas to which a proper amount of air can be admitted and burned in a combustion chamber which is sufficiently large to allow of complete combustion in the furnace.

DRAFT.

In considering any type of furnace, one should keep in mind the necessity of having a strong draft available. This may be provided by a stack or a fan. A stack may be supplemented by a force draft fan or an induced draft fan may be used alone or in connection with a forced draft fan. Most plants do not have sufficient draft at times when boilers are overloaded.

The amount of draft required depends upon the kind of coal used, the size of the coal and on the load to be carried. Stacks should seldom be less than 120 feet high. In many cases they must be higher or a fan used with them. For most bituminous coals a draft or difference of pressure of one-fourth inch of water between the top and bottom of the fuel bed will be sufficient. For small sizes of bituminous coals and for the various small sizes of anthracite coal, the draft required is greater. For buckwheat sizes of anthracite, a draft of one inch of water is frequently necessary.

CHOICE OF COALS.

General.—Because a coal is sold at a low price per ton does not of necessity make it the cheapest coal to buy. In choosing a coal when the furnace equipment and other conditions are favorable, the one giving one million heat units for the lowest cost will prove to be the most economical to purchase. As a rule, coals mined near the point of consumption and bearing only a small freight charge will be the cheapest coals to purchase, and, in most cases, it will pay to install a suitable furnace to burn them.

An engineer having full information before him may then decide whether his furnaces are suitable for burning the cheapest coal or whether it will be profitable to change the furnaces.

It often happens that, for some good reason, it is impossible to change the equipment and in this case it is, of course, necessary to choose a grade of coal which will make it possible to generate the steam required even though it be more expensive. These conditions arise especially in plants belonging to government or state institutions and in plants which are rented.

In considering coals for boiler plants, one must be familiar with the kinds and grades of coal available, their chemical characteristics and the prices, together with the furnace equipment to be used.

Certain characteristics of coal determine the method of firing or the design of furnace required to burn them most efficiently.

Among these are the tendency to clinker and to cake in burning. The amount and character of the volatile matter, ash and moisture are also important.

How to Select Coal.—In choosing coal for a boiler plant, it is probable that the chemical comparison is the more reliable, if based upon a representative sample of the coal, than a boiler test. The possibility of doing accurate work in a laboratory is greater than in a boiler room, where the fireman may unintentionally influence results by his method of handling a fire. Usually it requires a few days for a fireman to become accustomed to a new coal, and even an expert fireman has difficulty to burn the same coal two days in succession and supply the same amount of air per pound of coal each time. A boiler test is only a rough determination and two tests, one on each of two coals, are seldom sufficient for comparison. If several tests can be run and the averages of the results of these taken, they will compare pretty closely with the chemical valuation of the coal, provided the coals are of the same general character. Coals high in fixed carbon and low in moisture give better results than those high in volatile matter and moisture. This is true in nearly all furnaces and especially true of those not provided with fire-brick furnaces.

Size.—In the perfect furnace which has been mentioned, the value of the coal should depend entirely upon the heat units which are available in the coal. This being so, the heat value would be the true basis for the purchase of coal. Unfortunately, as has just been mentioned, the sizes of the coal, even though it is otherwise equally high in B. t. u., is an important element in burning the coal on most kinds of equipment. Usually the smaller sizes are more difficult to burn on account of the difficulty of drawing air through the fuel bed, and in many kinds of coal the smaller sizes contain a greater percentage of ash than do the larger sizes.

Owing to the difficulty of burning the smaller sizes of coal, they are usually much cheaper than the larger coals. Improved furnaces with strong drafts have been provided in so many plants that very little coal is being wasted today on account of its size. The culm banks of the anthracite region are being put through washeries and the good portion sold for fuel. Many coals break up badly in handling. This is especially true of some of the high-grade eastern coals. Some of them are

delivered with 20 per cent fine coal which will pass through a screen with round holes one-eighth inch in diameter. If the coals cake in burning, this is not so serious as with noncaking coals. With fine coal a much stronger draft is required, which, in some cases, carries a considerable quantity of the very fine fuel off the grate before it is burned, and in case it does not cake there is also a considerable loss due to sifting through the ash pit.

Chemical Characteristics.—The results of more than 600 steaming tests conducted at the Fuel Testing Plant of the U. S. Geological Survey show that with the equipment used coals from Illinois, Indiana, Kentucky, Iowa, Missouri and Kansas may all be burned with practically the same efficiency, even though the heating value varies from 8,000 to 13,000 B. t. u. per pound of coal, the ash varies from 8 to 25 per cent, the moisture varies from 3 to 20 per cent and the volatile matter varies from 30 to more than 40 per cent in these coals.

Influence of Heating Value.—The results of these tests indicate that for coals of the same general character the performance of a boiler depends, for the most part, upon the B. t. u. available in the coal; that moisture, volatile matter, sulphur and ash have more or less influence on the capacity and efficiency. It is difficult to separate the effects due to any one of these items, except when they occur in large percentages. Coals of the same character may be compared directly on the basis of the B. t. u. in the coal as received without serious error. It is important to note that the heating value should be considered on the basis of the moist coal "as delivered" and not on the dry coal (See table II). Coals of different character may be compared on the basis of their B. t. u. values, but account must also be taken of the percentage and character of volatile matter, the percentage of ash and the percentage of moisture. An allowance for these must be made, depending on the conditions under which the coal will be used.

Influence of Moisture.—The loss due to moisture in the coal when present in small percentages is comparatively small. Stated roughly, this loss amounts to about 1 per cent for each 10 per cent of moisture, based on the "combustible" in the coal. It will, therefore, be seen that an increase of 1 or 2 per cent of moisture in the coal has but little effect on the efficiency of the boiler. However, when moisture occurs in large percentages, as it does in some coals, there is a serious loss due to the heat required to evaporate this moisture from the coal and to the reduction in temperature of the furnace gases. This loss is not corrected for in chemical reports on B. t. u. in coal, and an allowance should be made if a coal is high in moisture. This would correspond to the so-called low B. t. u. value of gas and liquid fuels used in internal combustion engines (See last column, table II).

In order to make clear the relation between the different forms of reporting coal analyses and to show the influence of moisture in coal when both moisture and ash are present in varying amounts, the following tables have been prepared.

Influence of Ash.—It is difficult to determine just what effect the presence of ash may have on the efficiency of the boiler. Apparently it is small. Ash has, however, a decided influence on the capacity at

which a given equipment may be operated; it reduces the effective grate area and introduces an added resistance to the flow of air through the fuel bed. There is also a loss of efficiency and capacity due to the necessity of cleaning fires more frequently. This becomes of less importance in types of furnaces where the ash is discharged by dumping or other automatic discharging devices.

Influence of Volatile Matter.—The volatile matter in the coal is also an important element, as it is more difficult to burn than the fixed carbon. The percentage of volatile matter, as shown by the proximate analysis, is not a direct measure of the difficulty of burning the coal with good efficiency and without smoke. Different coals having practically the same percentage of volatile matter vary in the amount of tars and heavy hydrocarbon given off when they are heated.[1]

In addition to the above, it must be remembered that the volatile matter is not all combustible material and the variation in this respect is

TABLE I.

Proximate analyses of coals from different parts of the United States. (See Prof. Paper 48, U. S. Geological Survey.)

	Proximate analysis of Coal as Fired.				
	Fixed Carbon.	Volatile matter.	Moisture.	Ash.	B. t. u.
W. Va. 8	56.68	31.19	5.26	6.87	13677
Ill. 1	38.21	36.91	9.69	15.19	10706
Mo. 3	29.98	26.18	18.63	25.51	7758
N. Dak. 1	25.40	28.13	35.84	10.63	6674

TABLE II.

The influence of moisture and ash in coal on the B. t. u. values and on the heat units available to the boiler. Same coal as in table I.

Coal.	Comparison of B. t. u. Values.			Comparison of Ash.			Moisture.		
	B. t. u. as fired.	B. t. u. dry coal.	B. t. u. "combustible."	Ash in coal as fired.	Dry coal.	Ash "combustible."	In coal as fired.	Moisture "combustible."	Heat loss due to moisture in coal per cent combustible.
W. Va. 8	13,677	14,436	15,564	6.87	7.25	7.83	5.26	5.99	0.49
Ill. 1	10,706	11,855	14,252	15.19	16.82	20.22	9.69	12.90	1.15
Mo. 3	7,758	9,535	13,817	25.51	30.99	44.90	18.63	33.17	3.16
N. Dak. 1	6,674	10,402	12,466	10.63	16.56	19.85	35.84	67.00	6.70

[1] See paper by Porter & Ovitz in American Chemical Journal.

very great when all the coals in the country are compared. Coals having a high percentage of volatile matter which is nearly all combustible are found to be the most difficult to burn properly. The results obtained from tests on an iron-enclosed furnace show a drop in efficiency as great as 10 or 12 per cent in burning coals ranging from 18 down to 45 per cent volatile matter in the "combustible." A well-designed furnace reduced this loss in efficiency when burning such coals to about 5 per cent. A perfect furnace would, of course, obtain the same efficiency from all coals.

Influence of Sulphur.—Sulphur is considered an undesirable element in coal. It usually gives trouble from clinker and is sometimes destructive to the grate bars. Its effect depends upon the form in which it occurs in the coal; on the percentage of ash in the coal. Coals having sulphur varying from ½ per cent to 6 per cent or more are successfully burned under boilers, and, in many cases, no difficulty is experienced.

PURCHASE OF COAL FOR GOVERNMENT.

The United States government is a large user of coal. Its fuel bill will amount to nearly ten million dollars. Much of the coal purchased is tested and analyzed. One single contract for this year was 400,000 tons of coal to contain 14,600 B. t. u. per pound.

In order to compare the cost of coals used by the government in the larger cities of the country, it has been customary to calculate the cost on the basis of the number of cents per 1,000,000 B. t. u. It is interesting to note that for last year's contracts the cheapest coal was delivered in Louisville costing only 7.1 cents per million B. t. u. The cost in Boston for similar coal was 16.3 cents and in St. Paul the price was 17.1 cents. Anthracite coal was delivered in eastern cities at prices ranging from 8½ cents per million B. t. u. for Buckwheat coal to 14 cents for Pea coal and as much as 20 cents in some cases for Egg and broken coal.

Specifications.—Having decided upon a kind of coal to be used for a plant, the purchaser naturally desires to have some assurance that he may be able to secure the coal in question, or one of practically the same composition, for a given period. This has led to the use of specifications for the purchase of coal. If the size of the contract and other conditions warrant the use of a specification, then the proposal for coal to be of value should contain at least two general statements regarding the kind and character of coal.

Proposals for Coal.—The bidder should state in his proposal:

1. The commercial name and size of the coal to be furnished. The size should be specified within certain limits in order to avoid disputes when coal is delivered.

2. The character of the coal to be furnished, in the following form:

PROXIMATE ANALYSIS.

	As received.	Dry coal.	Free from moisture and ash.
Moisture..........	....		
Volatile matter	....		....
Fixed carbon	....		
Ash..........	....	....	

Sulphur separately determined ....—————per cent.
B. T. U. in coal as received (not dry)..........—————

The price per ton should be stated for coal of the specified quality. The price to be paid on coal delivered should vary directly with the B. t. u. in the coal "as received"; this value to be modified further, if advisable, by corrections:

1. For more or less ash in the dry coal.

2. For more or less volatile matter in the "combustible," allowing in all cases 2 per cent or 3 per cent variation without premium or penalty. A limiting value may be placed on the percentage of sulphur in the coal which will be accepted. Corrections for ash and volatile matter are best expressed in the form of a table. In making corrections for variations in the qualit-- of the coal delivered, it may, in some cases, be more convenient to make all changes in the price on the basis of change of the B. t. u.

The Reasons for Basing Contract on Items Mentioned Above Are as Follows.—1. "B. t. u. in coal as received" corrects for changes in heating value due to changes in both ash and moisture.

The B. t. u. in the coal as delivered being the most direct measure of its value to the consumer, it is reasonable that the contract should be based principally upon this value. This value may be determined and reported directly by the chemist. This results in a premium for better coal and a penalty for coal not up to the standard.

As has been shown above, so far as is now known the presence of small amounts of moisture in the coal has but little effect on the efficiency of the boiler, and, as coals from the same mine or group of mines do not usually vary more than 3 per cent or 4 per cent in moisture, it hardly seems worth while to correct for the small amount of heat lost in evaporating it. By basing the value of coal on the B. t. u. as received (moist), the variation in heating value as otherwise affected by the moisture are provided for.

2. "Ash in the dry coal" is independent of changes in moisture in the coal, this figure always being the same no matter what the moisture content may be. Coal delivered from the same mines may vary considerable in the percentage of ash. A reasonable allowance, such as 1 per cent or 2 per cent from the average, would seem to be desirable, as

such a variation is almost unavoidable in commercial products. Inasmuch as the heating value is taken care of by the B. t. u. determinations, the only remaining correction to be made for the ash is the extra trouble in handling the coal and ashes and the possible reduction of the capacity of the equipment. When the ash greatly exceeds the amount for which the furnace was designed the reduction in capacity may become a serious matter and would justify a rapidly increasing penalty. For the first 3 per cent or 4 per cent increase or decrease in the ash it is only necessary to provide for the difference in the cost of handling, which is between ½ cent and 1 cent per ton for each 1 per cent of ash in the coal. If corrections other than for B. t. u. are to be made, and the ash is a factor, the specifications should be based upon the percentage of ash in the dry coal for reasons which are explained elsewhere.

3. If volatile matter is to be corrected for, then "volatile matter in 'combustible'" is preferable to "volatile matter in coal." It should be the same, or nearly the same, regardless of variations in moisture and ash in the coal, and it is more properly a measure of the difficulty to be experienced in burning coal, as it is the direct ratio of the volatile matter to that part of the coal which is actually burned. It is reasonable to have a penalty for great variations in the volatile matter from the standard specified, for the reason that furnaces are not all equally well designed to burn coals high in volatile matter. This should not in any way affect the dealer or operator, provided the coal is furnished from the same mine, as the volatile matter should remain practically constant and a reasonable limit should be established within which no change in the price would be made. This variation could well be 3 per cent either way from the standard established. The value for volatile matter should be based on volatile matter in the "combustible" (coal free from moisture and ash), as this value remains nearly constant in the same coal. Premiums or penalties for lower or higher volatile matter may properly vary according to local conditions.

4. Sulphur. Sufficient information is not available on which to base a reasonable rate for correction for this element.

Remarks on Mine Rescue Work.

(By Dr. J. A. Holmes, Chief of the Technologic Branch U. S. Geological Survey.)

There are three matters about which I wish to caution the members of the Conference and wish them in turn to caution others. The rescue movement must overcome great and varied difficulties. Its field is very broad and its accomplishments should therefore be correspondingly very large. With work of this extent results can not be accomplished in a day or a night. You, gentlemen of the Conference, must therefore, first, not get out of patience if you do not see immediate and direct practical improvements. Second, you must keep patience with the work of the oxygen helmets. If some difficulties are encountered in their operation and if defects in them develop, do not too hastily condemn them. They have done good work and will do better work. Like other comparatively new inventions they need to be perfected. Remember, too, that the man must be educated to their use and that greater familiarity with them will remove many of their apparent deficiencies. Third, do not get impatient with the rescue work if disasters still occur. In the face of the extensive work of this kind carried on in some of the foreign countries there have been appalling disasters, but continued patience because the cause of these accidents were traceable to carelessness or to failure to comply with the law. The general ratio of men engaged to men injured has been very greatly decreased as the results of the work done abroad.

In explanation of the terrible disaster that occurred in France I had the pleasure of inspecting this mine very thoroughly about six weeks prior to the disaster and the mine was being managed in a thoroughly approved manner. The cause of this accident is still in doubt. The two recent and very serious disasters in Germany occurred on Monday after the mine had been shut down all day Sunday and Sunday night when no sprinkling had been done and the dust was fairly well dried out. This was probably the cause of the trouble. One of these accidents occurred after a long drought when it is claimed the water supply of the mine had long been exhausted, although it is claimed by the operators of the mine that there was ample supply for all purposes.

The effect of this careful work is shown in the decreased number of injuries per man employed, and in this great work little Belgium has the best record in the face of having the most dangerous conditions under which to operate of any country in the world. I had the privilege of inspecting Belgium's most dangerous mine and am pleased to say that even though this mine is probably the most dangerous mine in the world

there has been no accident in it for seventeen years except one which was due to carelessness or infraction of the rules of the mine. A miner, in attempting a joke on some of his fellow-workers, attempted to stop a lift by inserting an iron crowbar in its mechanism. This caused the fatal spark.

In the United States we must do the best we can with the means at hand to overcome the difficulties that have been outlined during this conference and which we have to face. By patience and continued untiring effort we may yet make mine disasters impossible by removing the cause. The output of the coal mining industry of the United States is more valuable than the products of the mines for precious metals. Schools of mines have been established by a number of the technical colleges of the country, but most of their attention is given to the mining of metals and very little thought or effort has been expended toward education as to the economic methods of recovering coal. It seems to me that this oversight or indifference to the production of coal should be remedied, especially in such states as Illinois which rank among the first in the output of coal. I would be glad, indeed, if the State of Illinois and other coal-bearing states would establish departments of mines in their universities, giving especial attention to the mining of coal. It seems to me that this Conference should not permit the present session of the Legislature to be adjourned without putting before it the request of the coal and commercial interests which are allied, for the establishment at the University of Illinois of a department of mines. In conclusion I would like some one to start such a movement by appointing a committee to present the matter to the Legislature.

Remarks on Economy in the Use of Fuel.

(By Mr. E. H. Taylor, Fuel Engineer, Chicago, Ill.)

There are wastes of coal in many large establishments, but in many other such plants, means have been taken to economically consume fuel. These improved methods have been brought about in Chicago very largely by education and have been influenced greatly by the work of the Engineering Experiment Station of the University of Illinois and by the students of Illinois employed in Chicago. These savings and improvements have in many cases been brought about by no change in the plant. While it is true that much saving has been effected, I would like to see it increased, and especially in small plants; the home in particular. In my own home, by studying the conditions of the furnace I have been able to save on this year's fuel about $30.00 or 25 per cent of my coal bill. Education of the people in the matter of burning coal would undoubtedly save more than at first would be realized; and I am sure that if the interest of the public is enlisted on the side of the rescue movement, and on the side of education with regard to fuel, there is no other project which will become so quickly popular with the mass of the people.

Fuel Tests with House-Heating Boilers and Hot-Air Furnaces.

(By J. M. Snodgrass, Engineering Experiment Station, University of Illinois.)

The equipment with which the Engineering Experiment Station is at the present time making house-heating fuel tests consist of two house-heating steam boilers and one hot-air furnace. One of the steam boilers is built up of horizontal sections, the heated gases passing upward from the fire through the sections to the smoke pipe. The other steam boiler is made up of vertical sections, the heated gases leaving the fire-box at the rear, traveling to the front of the boiler and returning to the smoke outlet at the rear through suitably arranged flues. The hot-air furnace is of cast-iron construction, surrounded in the usual manner with a galvanized iron casing. Each of the steam boilers is provided with suitable apparatus for weighing and supplying feed water and with such other apparatus as is required for test purposes. The hot-air furnace is supplied with an air-measuring device consisting of a fan-blower and gauging-box for the purpose of measuring the amount of air heated by the furnace. Thermometers, draft gauges and other testing apparatus make up the equipment.

The purpose of the tests has been twofold: First, to obtain information as to the relative value of the various fuels commonly used in house-heating work in the State of Illinois, special attention being paid to Illinois coal in the effort to promote a more general use of that fuel and to make the conditions under which it is burned more satisfactory; secondly, to obtain information that would assist in developing satisfactory methods for testing house-heating boilers. Up to the present time about 120 tests have been conducted upon anthracite, Pocahontas and coke. The others have been made with Illinois coal. The following fuels have been burned in making tests:

1. Anthracite, Wyoming District, Pennsylvania.
2. Pocahontas coal, West Virginia.
3. Solvay coke, from Chicago market.
4. Gas house coke, from local gas works.
5. Illinois coal, Williamson county (several samples).
6. Illinois coal, Saline county.
7. Illinois coal, Christian county.
8. Illinois coal, Macon county.
9. Illinois coal, Vermilion county.
10. Illinois coal, Grundy county.
11. Illinois coal, LaSalle county.
12. Illinois coal, Tazewell county.

For a large number of the tests already made with the steam boilers the methods employed have been in the main similar to those employed when making tests upon power boilers. Comparatively large amounts of fuel have, however, been fired at one time so that the interval of time

between one firing and the next has lasted several hours, varying roughly from two to ten hours, depending upon the fuel, load carried and other conditions. The A. S. M. E. code for conducting boiler trials has been employed as a general guide. This method of procedure has tended toward laying the greatest stress upon evaporative performance rather than upon questions relating to cleanliness, control or attendance.

A series of forty-eight tests was run upon representative fuels with the two steam boilers all at a load of approximately 65 per cent of their rated capacity. Under these conditions the plant efficiencies varied from about 45 per cent to 65 per cent; that is over a range about the same or possibly somewhat lower than that found in power boiler work. The variation in efficiency was for the most part due to the composition of the fuel, that is, the fuels high in fixed carbon content as the anthracite and coke gave high efficiencies, and the fuels high in volatile content and ash, as the Illinois coal, gave low efficiencies.

The forty-eight tests just mentioned have led to some general conclusions, which may be stated as follows:

In considering house-heating boiler tests a number of important considerations, such as efficiency, fuel cost, attendance, control, cleanliness and equipment, must be taken into account. The relative importance of such factors can not be stated definitely, and vary greatly with the nature of the service required of any given installation.

Efficiency and fuel cost may become the items of greatest importance when heating work is upon a comparatively large scale approaching power-boiler conditions.

Simplicity and the ease with which the heating apparatus can be cared for may be of greater importance than high evaporative efficiency. The condition which requires the minimum amount of attendance may be the most satisfactory and economical and more than offset the consumption of some extra fuel.

The ability to get up steam quickly, and to maintain uniform pressure and fire conditions over comparatively long periods of time, may be of greater importance than questions relating to either fuel or equipment.

The desire or necessity for cleanliness, with respect to smoke, soot and dust or dirt, may warrant the use of high-priced fuel.

The efficiencies for the tests under consideration varied from about 45 per cent to 65 per cent. A still wider range will exist under the variable capacity conditions common to average residence heating work.

Present methods of burning and present types of boilers are particularly well adapted to burning anthracite and other coals high in fixed carbon content. Coke burning presents special problems as to methods of burning and construction of equipment.

The low efficiencies with the fuels of high volatile content and the variations in efficiencies indicated the possibility of obtaining higher efficiencies with the cheaper fuels by means of careful attention to details relating to fuel, operation and equipment.

Illinois coal may be obtained at from one-fourth to one-half of the cost of anthracite per ton. Roughly, the cost per British thermal unit is in the same proportion. Illinois coal is also considerably cheaper than Pocahontas coal or coke, expressed as cost per ton or per B. t. u.

Fixed carbon can be purchased much more cheaply in the form of coke than as anthracite. Fixed carbon can be obtained at as low or at a lower price in the form of coke than in Pocahontas or Illinois coal.

With Illinois coal as fuel, water can be evaporated in house-heating boilers at about 50 per cent of the fuel cost of anthracite and at about 75 per cent of the fuel cost of Pocahontas coal or coke.

The relatively low cost of Illinois coal, especially as compared with the eastern coals, will insure its continued use for domestic purposes. The amount of this fuel used for such purposes will increase in spite of the disadvantages connected with its burning. This condition emphasizes the necessity for improvement in the methods of burning the cheaper fuel.

The low fuel cost for Illinois coal as compared with coke is considerable and will insure the continued use of raw coal until prices of the two fuels are more nearly equal. Improvement in the methods of burning and equipment are needed for each of these fuels and such improvements will doubtless affect the relative quantity of each which is used.

Based upon present prices and considering evaporative performance only, anthracite, as compared to Illinois coal, is only worth from $3.00 to $4.00 per ton. The additional amount which is paid for it must be considered as expended for advantages possessed by the anthracite, such as cleanliness and ease of fire control, which are not possessed by the other fuel. Anthracite and coke possess marked advantages over the other fuels, especially over the Illinois coal, with respect to cleanliness. The practice of washing and sizing Illinois coal eliminates to a very considerable extent the objectionable features with regard to smoke, soot, dust, dirt and ash.

A report concerning the forty-eight tests which have just been considered is at present in the hands of the printer, and it is hoped will shortly be issued as an Engineering Experiment Station bulletin.

In addition to the tests above mentioned a further series of efficiency tests upon Illinois coal is in progress, also a series of tests when operating at capacities ranging from about 10 per cent to 100 per cent of the rated capacity of the boilers and a series of service tests in which conditions are comparable with those found in small residence heating work. It is hoped to use some of the data thus obtained or to run additional tests that will assist in developing a method of rating house-heating apparatus.

In all tests now in progress the hot-air furnace is being tested as well as the steam-heating boilers. For a number of tests already completed with the hot-air furnace efficiencies, in the neighborhood of 45 per cent have been obtained. In tests where capacities have been varied for a given fuel over a range of from about 10 per cent to 90 per cent, the range in efficiency has been from about 30 per cent to 60 per cent.

While not overlooking the importance of evaporative performance, it is expected that in future work and in the tests now under way much more attention can be given to questions relating to cleanliness, control, attendance and other important considerations.

THE U. S. GEOLOGICAL SURVEY AND THE FUEL RESOURCES OF THE COUNTRY.

(By George Otis Smith, Director, Washington, D. C.)

By law, the federal Geological Survey is charged with the classification of the public lands and the examination of the geologic structure, mineral resources and products of the national domain. Thirty years ago, Congress thus defined the scope of this branch of the public service, recognizing by the wording of the statute the practical relationship between geology and the mineral industry. Today the Geological Survey is making contributions to the nation's knowledge of its mineral fuel resources along four lines: Land classification, mining geology, mining technology and mineral statistics.

In one line, that of classifying the mineral lands, whose title remains in the national government, the federal bureau has an undivided jurisdiction; in the other phases of the investigation of mineral fuels, we share the field in common with the State Surveys and the great research schools. This Conference is especially significant in that it has been inspired by the spirit of coöperation. It therefore well expresses the extent to which these three agencies are working together in the service of the mining industry and indeed for the benefit of the whole industrial life of the nation.

In 1879 Congress expressed its appreciation of the importance of the nation's mineral wealth by establishing this scientific bureau charged with the investigation of these mineral resources. Now, three decades later, the mining industry is making an annual contribution to the nation six-fold greater than it was then. I shall refer later to some phases of this phenomenal thirty years development, but first a few words as to the part the U. S. Geological Survey has had in recording and promoting that development, that you may judge whether this bureau is, like your State Survey and University, in any sense keeping pace with the marvelous expansion in the production of mineral fuels and notable progress in their economical utilization.

In the first few years of its history, the Survey has an annual appropriation of between one and two hundred thousand dollars, very small portions of which appropriations were devoted to the subject of the nation's fuel resources. This year out of an appropriation of a million and a half, more than one-third or at least $600,000.00 has been expended in explorations and investigations relating solely to the mineral fuels. This work is both geologic and technologic.

Of the technologic investigations I need say little, as you have been able to learn their nature and to judge their value at first hand from Dr. Holmes, the Chief of the Technologic Branch, and his associates, Messrs. Rice, Randall and Williams. I would not care, however, to allow this opportunity to pass without mention of the spirit of enthusiastic endeavor that has characterized those who have been engaged in these past few years in beginning this new line of federal work.

As I stated a moment ago, these technologic problems have been and are shared with other organizations, whose members are equally enthusiastic and no less well qualified to master the problems. Yet from my observations I am convinced that the entrance of a federal bureau into the technologic field has given an impetus to the movement to secure less wasteful practices at both mine and power plant that no other single agency could have contributed. In making this statement I am not unmindful of the invaluable assistance received from Prof. Breckenridge, Goss and Lord and several others connected with colleges or universities, for it is such coöperation that has made possible whatever success has already been attained.

In view of the increasing dependence of our industrial nation upon its mineral fuels, I am inclined to take a high value upon the technologic cotributors of the U. S. Geological Survey. As you know, attention has been given not only to the waste in mining but more especially to the much greater loss in utilization, and now to this experimental work has been added the beginning of an adequate investigation of mine accidents, a line of practical research that is expected to decrease in some degree the present excessive loss of life in the mines. It promises well for the success of the mine accident and mine rescue work of the Survey—work barely begun—that so large a part of this Conference has been devoted to this humanitarian phase of our investigations.

In the geologic branch of the Survey the federal geologists are engaged in mapping and measuring the nation's stores of coal, oil and gas, and exploring the public lands with the purpose of adding to the visible and known supply of these mineral fuels. Since the organization of the Survey, its statisticians have been recording the ever-increasing activity of the country's coal mines and oil and gas wells, with the result that last fall we were able to present to those interested in national conservation a fairly accurate inventory, from which I shall later select some of the quantative data for graphic repetition.

The land classification work of the Geological Survey is its latest development, although the classification of the public lands was a function and duty specifically laid upon the bureau at the time of its establishment. For three years now an increasing amount of attention has been given to special surveys of the coal lands belonging to the government. The lands underlaid by valuable deposits of coal have been segregated from the noncoal lands—the latter restored to agricultural industry and the former protected from any entry other than under the coal land laws. In this movement to secure the proper utilization of the remaining public lands and their sale at prices somewhat proportionate to their value, the function of the Geological Survey is not only to determine and

report to the General Land Office the coal or noncoal character of the land, but also to place upon each legal subdivision—or forty acres—of the coal land a selling price. In this valuation work, the accessibility of the coal field, the number, thickness and depth of the coal beds, and the quality of the coal are all factors considered in the determination of the coal values.

This classification of the public lands in the past three years has resulted in the field examination of about 35,000,000 acres—an area nearly equalling that of the whole State of Illinois.

This recent departure in Survey explorations is a noteworthy example of geology applied to the public good. Yet, incidental to this purely economic work, important scientific results have been secured relating to the stratigraphy of the Rocky Mountain province. Systematic surveys of the oil fields are likewise yielding data, both economic and scientific, of equal importance; but with so great activity in the coal fields, the federal Survey has been unable to keep abreast of the oil and gas developments in the different fields.

The field and laboratory work of the Survey, the explorations and investigations, realize their full purpose only as the results are published. Publicity through the preparation, publication and distribution of reports is the measure of success and the Survey's contribution to the knowledge of the fuel resources of the country is indicated by the annual issue of not less than ten geologic reports on the subject and a total of fourteen technologic bulletins since 1904, when the fuel-testing work was started at St. Louis. A gratifying feature of the publication side of the work is that a considerable proportion of these publications are already out of print, a fair index of public interest in the subject.

Returning now to the subject of our fuel resources, it may be well to consider the state of our present knowledge as to the extent and distribution of these supplies and of the tendencies of today in the production and consumption of the mineral fuels.

In 1901 the U. S. Geological Survey made its first attempt to compile an inventory of the nation's coal reserves. At that time the data scattered through technical journals and official reports were collected and a summary prepared of all available information. Dr. Hayes presented in a table the distribution of the coal fields and estimates of their extent. A comparison of this table of 1901 with the statement of Mr. Campbell of May, 1908, furnishes some idea of the amount of the Survey's work on coal in the intervening seven years. The earlier inventory gave the area of coal bearing formations in the United States as 280,000 square miles, of which only certain percentages, 35 to 75 per cent, were believed to be workable. The later figures are for workable coal fields with an estimated area of 327,000 square miles with nearly one-half as much more of possibly workable coal and coals under heavy cover. The more notable differences between the two tables are in the Rocky Mountain states, where the Survey has been engaged in land classification, where the later figures double or treble those of the earlier inventory. Again, in the earlier summary, no attempt was made to estimate tonnage, inasmuch as at that time data relating to number and thickness of workable beds were not available for large areas of the country; but in the 1908 state-

ment Mr. Campbell estimates not only the available tonnage, but classifies the coal reserves by provinces, accessibility and grade of coal. This estimate has been criticized as too large for Pennsylvania, West Virginia and Ohio, but it may be stated as probable that any overestimate in the eastern fields will be offset by underestimates in the Rocky Mountain fields.

Turning now to production statistics, which, in the case of coal, oil and gas, form the best possible test of industrial progress, a few notable changes since 1880 should be mentioned.

In a list showing the present relative importance of the ten leading mineral products, the mineral fuels coal, oil and gas will be seen to rank first, fifth and ninth. Were we to compare this with the sequence of 1880, you would find that notwithstanding the sixfold increase in total value of mineral products, coal and petroleum have both maintained their positions, while natural gas is a new comer in the list.

With this increased prominence of the mineral fuels, it has naturally followed in these thirty years that the nonmetallic products have outshipped the metallic output, changing from 47 per cent to 57 per cent of the total. In the popular mind, too little credit is given to these most useful nonmetallic products and too much to the precious metals.

Petroleum and natural gas must be considered together with regard to their distribution. These areas are scattered over twenty-two states and aggregate nearly 9,000 square miles in six great fields. Eighteen states produced petroleum last year, and nineteen states natural gas.

The production statistics for petroleum for the past three decades are striking and show an eightfold increase, which fact, as you will remember, has enabled this product to keep its place in the column of minerals notwithstanding the great advances. It will be noted also that the center of petroleum production has shown a westward trend. In 1900 the primacy in petroleum production passed from Ohio to California and later back to Oklahoma.

When I come to speak more particularly of coal, I realize that I am in Illinois, a State standing near the front in both oil and coal production. I am not unmindful that as early as 1679 the Jesuit missionary, Father Hennepin, mentioned and mapped Illinois coal, and that today you rank second in both annual and total production and first among eastern states in coal reserves. But I can not refrain from bringing to your attention the fact that in only two foreign countries does the coal output exceed that of this State. In fact, you have two counties whose 1907 production exceeded that of Canada, or, indeed, of any one of twenty-three of our own coal producing states.

This wealth in the two important fuels, together with the nearness to the Lake Superior iron ores, puts your State well to the front in industrial importance.

The abundant supplies of coal and iron in this country form the corner-stone of our national prosperity. It has been stated that a nation possessing both coal and iron is independently rich, and you well know that America's industrial supremacy among the nations of the world depends upon her unrivaled reserves of iron ore and especially of the mineral fuels.

It is not without significance, therefore, that coal of some grade is found in all but fourteen states, and that thirty-one states and territories produced coal last year. The subject of coal production should not be passed over without mention of its phenomenal increase—a record that forms a true index of the nation's industrial growth. Only one curve can well be compared with this diagram showing the annual increase in coal output, and that is the increase in railroad mileage in the United States. The similarity is not only striking, but is expressive of the sensitiveness of both coal mining and railroad construction to general business conditions. The average annual increase figured from the production curve is something over 7 per cent. To show America's place as a world power, we have only to glance at the statistics of the world's production of coal. As far as known we lead the world in coal reserves as well as in present production. Nor can we look to China for coal, since when China becomes industrially awake, that great nation will furnish a home market for her own coal. Since the days of Von Richthoven's estimate of the coal resources of North China, that country has been looked upon as possessing a reserve upon which other nations may draw when the coal supply of Europe and America shall run low. Mr. Willis's recent estimate on the coal of North China puts the figures at 605 billion tons, with the qualifying statement that this may be 100 billion tons too much or too little. Such a reserve is fairly comparable with the total amount of coal in the Appalachian coal fields as estimated by Mr. Campbell. In short, the coal fields of southern, western and northern China are sufficient for only the future needs of the great civilization which the Chinese will surely develop.

This glance at the world's reserves of coal shows plainly that in the case of no mineral is there greater need to emphasize the folly of exportation of raw material. Let us keep our coal at home and with it manufacture whatever the world needs.

The relative size of the coal fields in the different states is indicated on this diagram. In this, however, there is no distinction as to grades of coal, and with the range of variation that we know, this should not be lost sight of. This feature is brought out on this copy of the map of the coal fields of the United States issued last year by the Survey. On this map is also indicated the progress in the center of production of coal in the two past decades in which, as you will remember, the production has nearly quadrupled. The center of the coal reserve of the nation is also indicated. These geographic features in the distribution of coal production and of coal reserves furnish the best illustration of how the distribution of mineral wealth must surely work out the line of national progress in material matters.

This review of our industrial development, a development so unpresidented as to lead us to doubt our ability to forecast the future with any degree of certainty, has little value, except as it convinces us of the need of increased effort to efficiently utilize the mineral resources of state and nation, and to discover new stores of those minerals that are essential to our prosperity.

The Illinois State Geological Survey and the Fuel Interests of the State.

(By Dr. H. Foster Bain, Director.)

Coal-bearing rocks underlie three-fourths of Illinois, including eighty-five of its 102 counties. The coal area is estimated at from 36,000 to 42,000 square miles—the largest area of bituminous coal within any single state. There are approximately 1,000 mines in the State, of which over 400 are railway shipping mines. The work of the State Geological Survey is therefore very largely devoted to coal and the problems of the coal fields.

Illinois ranks second among the states in the production of coal. In 1907 51,317,146 tons, having a total value of $54,687,382.00 were mined. The figures for 1908 are not complete, but preliminary estimates indicate that Illinois was almost alone among the states in holding its production. While in the country as a whole the amount mined fell off from 15 to 20 per cent, Illinois mines produced as much as, or possibly more than, in 1907, a record year.[1] Despite this gratifying fact it remains true that our mines are not working to anything like their capacity. In 1907 the average number of days worked was 218. It would probably be fair to assume 300 working days a year as possible. On this basis there was a loss of 30 per cent of the possible working time and this is not an unusual per cent of loss in our State. The reasons for this are complex. In part they lie in the nature of the coal which prevents its storage without spontaneous combustion; in part, in the general ignorance as to correct methods of firing and the real value of the coal; and finally in part, in the present organization of the industry with excessive competition in selling. The net results are bad for the industry and therefore for the State as a whole. Cheap coal reduces manufacturing costs but allows wasteful burning. It also entails wasteful mining and even prevents the introduction of methods of safeguarding the men in the mines. It is a serious question whether we are not paying, in loss of life in the mines, in loss of efficiency in our plants, and in loss of interest and capital invested in the industry, more than the cheapness of the coal is worth.

The study of the coal and coal fields of the State has been carried on both in the field and office. The work has been directed toward:

[1] This prediction did not come true as the final figures show 47,659,690 tons. This loss was, however, low in comparison with that in other states.

1. The solving of problems of stratigraphy, such as the distribution and correlation of various coal beds, together with the collection of all data relating to the origin and the mode of deposition of the coal and accompanying beds.

2. A study of the composition and uses of coals.

3. A study of the mode of occurrence of coal as relates to the methods and costs of mining.

4. A study of the preparation of the coal for the market, its transportation, its normal markets, and the competition which it meets.

The first step in the solution of the problems of stratigraphy is the making of accurate detailed maps and the compilation of drill records. This is now being done and considerable areas near Peoria, Springfield, Belleville and in the Saline and Williamson county fields have been surveyed in coöperation with the U. S. Geological Survey. These maps show the thickness and lie of the coal beds and from them it will be possible to tell quite exactly how much coal is present and to plan its economical working. At present it is only possible to guess at the original content of the field and these guesses vary from 136 billion to 240 billion tons. Either is, perhaps, sufficiently large for our comfort.

The study of the composition of the coal is directed especially toward the determination of its availability and the best means of using it. Samples are taken by uniform methods in the mine and in the market and in connection with the Engineering Experiment Station elaborate experiments are being made of the methods of storage, of handling the coal, and of burning it. We hope soon to take up the matter of gas production and coke-making and have had under way for sometime certain preliminary experiments.

The mode of occurrence as relates to mining methods and costs has been barely touched. In my judgment it would be well if the State made separate provision for this work. In the absence of special provision we are attempting to gather such notes as we can in the course of our regular work. "It has been found impracticable at the present time, mainly owing to limitations of funds, to undertake certain highly desirable studies of the technology of the mining industry and of the geographical distribution of markets for Illinois coals. It is believed that much good would result from investigations along these lines and that certain portions of the work are well within the proper field of the State Geological Survey. It is now well known that there is, under present commercial conditions, an enormous waste in the mining of Illinois coal. In individual districts it has been estimated to amount to as much as 60 per cent, though, of course, such losses are not general. It would, however, probably be safe to say that in very many places 40 per cent of the coal in the ground is left unmined or is ruined in the process of mining. In addition, the methods of mining introduced in recent years have greatly increased the production of fine sizes and have also, seemingly, increased the danger to life and property in the mines. The causes for all these losses are complex, and it is not to be supposed that either operators or miners willingly submit to them. Neither is it to be expected that the losses of life and property can be entirely done away with. At

the same time experience has abundantly proven that careful and impartial investigations of such conditions will point the way to the remedying of some at least of the abuses, and in view of the enormous importance of the subject to the State and the public at large, such studies are believed to be amply warranted.

There has been no opportunity as yet to seriously take up the study of markets. "The expansion of markets for Illinois coal is a matter of vital importance to the coal industry and indirectly to the people of the entire State. One of the most important means of promoting this expansion is by removing certain misapprehensions as to the quality of the coal and the pointing out of better means of burning, so as to increase its efficiency and decrease the smoke produced. This work has been taken up vigorously by the Engineering Experiment Station, which has published excellent bulletins on "How to Burn Illinois Coal Without Smoke" and other similar subjects. In addition to this valuable work, there should be investigations of the actual markets for the different grades of coal and of possible enlargements of these markets. There are large areas to the northwest within which Illinois washed coals might profitably supplant eastern coals now being sold. There are other areas to the south and west where, with proper organization of transportation agencies, even in advance of improvement of the rivers, trade territory could be gained. Any widening of the market would be of large benefit to the local industry, particularly if the summer market could be increased. For this reason the studies now under way relating to weathering of coal and coal storage are especially important."

Coal Analysis.

(By Professor N. W. Lord, Director of the School of Mines, Ohio State University.)

Within the last few years the subject of coal analysis has become of great importance to many lines of industry. The demand for the analysis of coal has come from a great variety of sources and largely from those having little acquaintance with chemical methods and the interpretation of chemical results. The chemists, on the other hand, have been compelled to take such methods as were found at hand, and the result of these conditions has been not altogether satisfactory in many ways.

If we consider somewhat in detail the various determinations made in the laboratory in connection with coal testing, it will be easy to show how much is commercial and how little what might be called scientific. The so-called analysis of a coal is usually a practical test of purity of the material on a small scale, but it also involves determinations which are supposed in some way to indicate the nature of the coal itself.

To illustrate, suppose we consider an ordinary sample of bituminous coal. It may be assumed to consist, first, of an organic constituent composed of vegetable residues more or less altered but retaining traces of its original woody structure and composite character and containing as an integral part certain inorganic components. Like its source, woody fiber, it absorbs moisture in damp weather and gives it up in dry weather. The ultimate chemical composition of this material varies with the extent of the alteration, as shown in the peats, lignites and bituminous and anthracite coals, and also, in all probability, with the nature of the vegetation from which it has been derived. This extremely complex and indefinite material may be called "coal substance" for want of a better term. Intimately mixed with this are inorganic substances, probably mechanically introduced with the original vegetable débris or else precipitated by secondary reactions from circulating waters. These may be in the nature of clays or fine sand and also intimately mixed iron pyrites. I have examined samples of coal under the microscope, in which microscopic crystals of pyrites were scattered through the mass in sufficient amount to give high percentages of sulphur in the total, yet in which a superficial examination of the coal itself practically showed no pyrites to the unaided eye. Other minerals may be present in the same way, even such unusual constituents as zinc blend, and, as Dr. Hillebrand has shown, considerable percentages of vanadium sulphide. The extremely complex nature of the organic constituents themselves may be inferred from the variable but sometimes very large amounts of sulphur they contain, well shown in the case of certain peats.

Now in addition to this base constituting the principal part of the sample submitted to the chemists for analysis, it has, secondly, more or less coarse admixture of slate, clays and other rock-like material occurring in connection with the deposits of coal and not properly separated in mining, bone coal, and also streaks of cannel and other associated materials, coal-like in character, but differing notably even in the organic material they contain from the coal itself. The fact that many of these ingredients on standing or exposure to air rapidly alter by absorption of oxygen, evaporation, etc., makes it appear that the problem is still further complicated.

Now some of the things that the users of coal wish to know and for which they turn to the chemical analysis in the hope of receiving information are the following: The heating power of the coal; the amount of ash or inorganic matter left on burning the coal; the nature of the combustion of the coal, whether flaming, smoking, rapid, or slow; the gas-producing quality of the coal both as to yield and as to the nature of the gas; the nature of the ash yielded by the coal, whether fusible or not; the amount of sulphur the coal contains; the coking quality of the coal and the purity of the coke produced; and the possibilities of improving its quality by coal washing.

In addition to the above are many questions of special character, such as the nature of the coal substance, the relation of its composition to the previous geological history of the deposit, and the relation of total heating power to the heating power actually available for technical operations.

What are the analytical methods at present used in the laboratory to meet this series of questions and to handle this very complex material? Most of the laboratory work is done upon a sample which represents or is intended to represent the average composition of the material and which in no way recognizes the separate constituents of the very complex mineral aggregate of which it purports to be an average. The methods therefore give results only approximately related to the coal substance and difficult of general application.

We have as of generally recognized importance the ultimate analysis as ordinarily made, giving the determination of the hydrogen, the carbon, the nitrogen and the sulphur and the percentage of ash left after burning. This analysis also includes an estimate of the oxygen by difference, which is, of course, only approximate, and has been frequently pointed out in discussions of the subject. This ultimate analysis is capable of a high degree of accuracy for certain elements, which I think could be safely stated as within 0.05 per cent in the case of hydrogen and perhaps 0.3 per cent on carbon, 0.03 per cent on the nitrogen and 0.05 on the sulphur. I do not mean that closer results are not obtainable, but ordinary work in the laboratory by competent chemists would, I think, run within these limits. The value of the ultimate analysis in all technical applications of the coal consists in its giving a reasonably accurate basis for the calculation of products of combustion and for comparisons with the heating power of the coal otherwise determined. The weakest point in the ultimate analysis is the uncertainty of its connections with the actual composition of the organic material as distinct from the impuri-

ties. Carbon, hydrogen and sulphur are present occasionally as carbonates, as combined water and as sulphates, respectively, in the slates and other mechanical admixtures, and the ultimate analysis does not distinguish between such occurrence and that in the coal substance. Ingenious efforts to eliminate these uncertainties as affecting the heating power by examination of various samples of the same coal differing widely in percentage of mechanical impurities have been made by several chemists.

In addition to the ultimate analysis, we have the more commonly made "proximate analysis," consisting of the determination of the moisture, ash, fixed carbon and volatile combustible matter in the coal. Much has been written in regard to these determinations.

On the same sample of coal closely agreeing results can be obtained on the ash and fairly close on the moisture. The variations in the volatile combustible is much larger and can only be kept within reasonable limits by very careful adherence to a defined method of procedure. The term moisture simply means the loss in weight under fixed conditions of treatment. It is intended and does bring the material to a condition which can be duplicated closely and represents a fixed basis for comparison, but in no wise stands for all the water in the coal. The volatile combustible, as has been carefully investigated by Professor Parr, is by no means properly named. Only a fraction, and a variable fraction at that, depending largely on the kind of coal, is combustible, and a considerable fraction, consisting of water vapor, carbon dioxide, nitrogen and other diluents is inert or noncombustible. It is well to recollect that the proximate analysis of coal was devised many years ago, and primarily as a means of testing the amount of coke left by coal. The volatile combustible has since been the subject of much discussion and many attempts have been made to correlate it with heating value, geological changes and the various questions arising in coal utilization. Some undoubted connections have been shown, but I feel that possibly too little recognition has been given to the empirical and more or less uncertain nature of the determination.

Of growing importance, particularly in connection with coal washing, and as a means for the study of coal samples, is the application of the separation by gravity or the so-called "float and sink" tests, in which the coal crushed to a moderate degree of fineness is separated on solutions of high specific gravity, chloride of calcium for specific gravities up to 1.35 and chloride of sulphate of zinc for higher specific gravities. Chloride of zinc solution can be made of a specific gravity as high as 2 and by dilution any of the intermediate gravities can be obtained. I have used this method in my laboratory for years to separate heavy mineral materials like slate and pyrites, as preliminary to the study of the composition of coal. The method is excellently adapted to tracing out the variations in composition as the intermixed mineral substances are eliminated. It will enable the experimenter to distinguish with considerable accuracy between the inherent intimately mixed ash and sulphur compounds and the coarser and mechanical contaminations.

In recent years the leading factor in the commercial valuation of coals has become the calorific value or heating power of the coal and today the most important demand on the laboratory is the determination of this.

The widely extending use of the bomb calorimeter is leading to new problems for the investigation of the chemists. Here again the heating value of the sample is modified more than by mere dilution by the nature of the mineral aggregate. As Mr. Turner and others have shown, the heating value is not entirely proportional in a given kind of coal to the residue left after deducting the ash and the moisture, but that there are factors depending on the influence of the inorganic material. Work of this kind is of great importance in order that the effect of ash, moisture and pyrites on the commercial value of coals may be more accurately known.

Calorimetry demands considerable training and experimental skill and the recently adopted policy of the Bureau of Standards of furnishing materials of known heating value so that the constants and correction of the calorimeter can be determined is greatly to be commended. The possibility of error in calorimetric determinations due to alteration of samples should be borne in mind. A very finely pulverized coal sample will oxidize in many cases very rapidly, and comparative results by different chemists on such a sample are liable to be very unsatisfactory unless all made at approximately the same time on samples that have been sealed in air-tight receptacles. Experiments made by the Fuel Testing Plant afford ample evidence of the extent to which this alteration may take place.

The determination of the water equivalent of the calorimeter experimentally gives rise to many difficulties and hence, except for those having had a great deal of experience in fundamental measurements, it is far better to use the calorimeter as a comparative instrument and depend for its constants upon burning substances of known calorific value such as are furnished by the Bureau of Standards. Commercial chemicals are quite variable and different samples of naphthalene, benzoic acid, etc., from different dealers will differ notably in their heating value. Recently the writer has obtained very successful results by the method of mixtures, adding hot water to the calorimeter from the Dewar flask or thermos bottle in which it is possible to read with great accuracy the temperature of the added water and to add the water to the calorimeter with only a very small correction for radiation loss during the addition. The method has proved successful in the hands of students who have made a number of water equivalent determinations agreeing within a very small limit of error with the calibration of the calorimeter obtained in other ways. Of course, this method has the advantage of being absolute and not relative.

The foregoing outline has dealt with the laboratory side of the question. All the analytical work, calorimetric work and everything else in connection with the testing depends for its economic value on the fundamentally representative nature of the sample of coal tested in the laboratory. Here is the weakest point in the commercial application of the results. Coal sampling is a matter now prominent before the technical world. Now that the extending recognition of the value of laboratory work is leading to the purchase of coal on chemical specifications the whole question of sampling is under review. Ingredients most affected

by sampling are obviously moisture, ash, sulphur, and calorific value. In a recent paper of great interest Mr. E. G. Bailey has presented a large number of results in which he criticizes existing methods and lays down certain general deductions from carefully conducted experiments as to the general principles involved in the securing of correct samples. Mr. Bailey has, in my opinion, done a very valuable piece of work both in calling attention to the importance of the subject and in the experiments that he has brought forward. As having been connected with the government work at St. Louis, I feel called upon to correct certain misapprehensions in regard to that work which I think have unintentionally on his part led him to place in a somewhat false light as to the accuracy with which the sampling was done.

As I follow his paper he makes a fundamental assumption that the variations in the portions of coal taken at the plant from the same car shipment and sent to the boiler, the gas producer and briquetting and washing plants were identical in composition with the car load samples and that the variations shown in these different portions were due to variations in sampling of the portions at the various plants, whereas, the facts of the case are that the different portions taken from the car were not supposed to be sampled from the car but simply portions unloaded at different points, and the reason why analyses were made of the separate portions was because it was recognized that the car load was not uniform as far as contents of ash, sulphur, etc., were concerned, and that the car load analysis could not be taken for the different portions without a preliminary thorough mixing of the whole car load, which was not practical. This is clearly stated on page 284 of Professional Paper 48, Part 1, from which I quote:

"It was intended that the car sample should represent the average of the whole car, while the other samples stood for different portions of it. These would average about five tons each. In some cases the car sample was taken on only a part of a car. The large variation in the different samples in a few cases shows the irregularity in the coal in the car."

Experiments were made at St. Louis and published in this same work, giving the analysis of duplicate samples, and, while the results were not very satisfactory and some errors were found, they were not of the magnitude given by Mr. Bailey from his comparison of the other samples based on the assumption which I have shown was not warranted and which was contrary to the facts as we stated them at the time. Mr. Burrows has discussed the question of mine samples, but the comparison of these with coal shipped from the mines makes no allowance for the extent of cleaning that the coal underwent in shipping and in taking the mine samples. As stated, several duplicate samples on the car loads were run to check the St. Louis sampling and the worst result obtained, I think, was the one given on page 287, in which an extreme variation in ash on a coal averaging 15 per cent ash was a little over 2 per cent. This coal was selected as the worst obtainable from the standpoint of sampling and the variation of the highest and lowest samples from the average of all the experimental samples on this coal was only a little over 1 per cent. Notwithstanding this criticism that I felt compelled to make of Mr.

Bailey's representation of the St. Louis work, I feel that this general proposition in regard to the uncertain nature of much coal sampling is well sustained. His conclusion as to the amount of sample necessary in order to obtain a representative sample are of great interest. However, I do not feel that the difficulties are quite as great as his experiments would lead one to conclude:

Two things are important to consider:

In the first place, that in crushing coal a large proportion of fine material is produced so that the average size of particle is but little more than one-half the maximum size and therefore results on the distribution of the maximum size pieces greatly aggregate the difficulties. I recently took four samples of screened coal and had them put through a jaw crusher and screened.

In No. 1, 8.8 per cent was retained by a ½-inch screen and 56.4 per cent passed a ¼-inch screen. This sample of coal was sampled in duplicate at this state of crushing, portions of coal of about five pounds being taken. The two five-pound portions were each separately pulverized, well mixed and analyzed. The first portion gave 13.86 per cent ash and the second portion 13.56 per cent. A similar experiment on a second sample of coal gave 16.3 over a ½-inch screen and 46.65 per cent through a ¼-inch screen. The ash in the first sample, 14.59; in the second sample, 14.49. A third sample of coal gave 7.3 per cent over a ½-inch screen and 48.3 per cent through a ¼-inch screen. The ash in the first sample was 15.11; in the second sample, 15.10. In two of these samples the percentage of ash in the finer portion was considerably greater than the percentage of ash in the coarser portion.

Of course, these results are too few in number to amount to anything, but they show that the finer material is in sufficient proportion to diminish the irregularity introduced by the bad distribution of the coarser lumps in the sample.

A further point in coal sampling which has to be considered is that in the larger sizes there is a natural mixture in the material of the slate and the coal, so that 4-inch lump coal does not represent a mixture of 4-inch lumps of coal and 4-inch lumps of slate to any appreciable percentage of the ash present. In other words, the inspection element must enter coal sampling, and no man would draw a moderate sized sample of a coal in which he has a large percentage of lumps of slate as large as the lumps of coal, while the occasional presence of even a large lump of slate would have but little influence on the ash percentage of the resulting sample.

Mr. Bailey gives what he names the "size-weight-ratio" of the relation between the maximum sized piece of coal in the sample and the weight of coal necessary to take in order that the sample may be certainly representative within an error of 1 per cent of ash.

Now, his figures lead to very large samples in cases of lump coal, but the foregoing indicates that the size ratio should probably be that of the maximum slate sizes present in the coal lumps, or free, rather than the actual coal lump size. The moderate variations in the ash percentage of the different lumps would have far less influence in disturbing sampling than the presence of equivalent sized lumps of slate.

Obviously, therefore, careful inspection must precede the sampling in the case of lump coal and the presence of large pieces of slate and pyrites in lumps in the coal taken into consideration in determining the size of sample necessary in order to properly sample the coal.

I have always directed samplers to inspect the coal carefully and break up into small pieces any lumps of slate, bone coal or pyrites found or anything else that did not look like coal before taking or dividing the sample.

Of course, it is well known that no system of sampling which is purely mechanical is satisfactory for materials in which coarse distribution of the components exists, unless the whole of the material is crushed to approximately such limits as are defined by Mr. Bailey. This is the principle involved in the sampling of lead and copper, and gold and silver ores, where the system of sampling involves the crushing of many tons of material. Such a system of sampling is, of course, out of the question with lump coals where the crushed material would be to a certain extent rendered of small value. The system of sampling adopted in this case must be based upon an estimate of the maximum size of slate and pyrites. constituting an important portion of the impurities.

The difficulty of eliminating the personal element in doing such sampling is one of the problems which the Committee on Specifications will have to contend with. Meanwhile, the sampling problem is before us and must be adequately solved before the laboratory analysis of the coal reaches its full application.

The preparation of the laboratory sample from the field sample is a much more simple matter and is easily within the reach of present methods. One of the principal difficulties involved at this point is the avoiding of changes in the composition of the sample due to loss of moisture and to oxidation. I notice in many experiments the coal is ground to 100-mesh or even 200 before analysis. I think this is a step in the wrong direction. The finer the powder the more prone to oxidation and loss of moisture, and I think the effort of the sampler should be to determine a lower limit for Mr. Bailey's "size-weight-ratio" as well as a higher, and not to reduce the sample beyond this point, before weighing out for analysis.

We have considered that a 60-mesh sample will meet the ordinary requirements where 1 gram is taken for the determination, which is within Mr. Bailey's figures as I understand them.

Registry of the Conference.

Alexander, John, Gen. Mgr. The Chicago-Herrin Coal Co., and The Carterville & Herrin Coal Co., Herrin, Ill.
Allais, A. L., United Coal Mining Co., 1717 Fisher Bldg., Chicago, Ill.
Bain, H. Foster, Director, State Geological Survey of Illinois, Urbana, Ill.
Balke, C. W., Associate in Chemistry, University of Illinois, Urbana, Ill.
Bement, A., Consulting Engineer, 2114 Fisher Bldg., Chicago, Ill.
Bent, E. T., Secretary Illinois Coal Operators Assn., 1110 Fisher Bldg., Chicago, Ill.
Bird, Paul P., Chief Smoke Inspector, of Chicago, 130 Reaper Block, Chicago, Ill.
Blatchley, R. S., Assistant Geologist, State Geological Survey, Urbana, Ill.
Bliss, Frank W., Chemical Bldg., Urbana, Ill.
Breckenridge, L. P., Director Engineering Experiment Station, Urbana, Ill.
Buchanan, Gordon, President Wilmington Star Mining Co., 1125 Old Colony Bldg., Chicago, Ill.
Burris, W. S. ,State Inspector of Mines, Duquoin, Ill.
Carroll, P. H., Supt. of Mines, Herrin, Ill.
Crawford, A. W., Montgomery County Coal Co., Hillsboro, Ill.
Crawford, G. W., Mine Operator, Collision, Ill.
Crawford, John G., Fuel Engineer, C., B. & Q. R. R., 209 Adams st., Chicago, Ill.
Crawford, O. W., Collison, Ill.
Daenzer, A., Glen Carbon, Ill.
Delano, F. A., President the Wabash R. R., Western Union Bldg., Chicago, Ill.
DeWolf, Frank W., Assistant, State Geologist, Urbana, Ill.
Dillavou, J. M., Champaign, Ill.
Dodge, D. L., Champaign, Ill.
Doughty, Jas., 121 Pine St., Danville, Ill.
Dunlop, John, State Inspector of Mines, Peoria, Ill.
Eaton, Lestre B., Duquoin, Ill.
Ellis, A. J., University of Illinois, Urbana, Ill.
Epperson, James, Chief Mine Inspector, Linton, Ind.
Evans, W. A., Commissioner of Health, Chicago, Ill.
Felgenhauer, Johan, Danville, Ill.
Fisher, Frank R., Springfield, Ill.
Fletcher, R. D., Supt. Chicago, Wilmington & Vermilion Coal Co., Thayer, Ill.
Foord, James L., 169 Jackson Blvd., Chicago, Ill.
Forester, Robert J., Duquoin, Ill.
Forester, James, Hallidayboro, Ill.
Forsyth, Wm., Min. Engr., Railway Age Gazette, 160 Harrison St., Chicago, Ill.
Gibbons, Foster, Farmington, Ill.
Gilchrist, H. M., Supt. Alden Coal Co., Farmington, Ill.
Goss, W. F. M., Dean of College of Engineering, University of Illinois, Urbana, Ill.
Grant, U. S., Northwestern University, Evanston, Ill.
Guthrie, F. M., Supt. Spoon River Coal Co., Galesburg, Ill.
Halbert, J. A., Westville, Ill.

Halbert, Wm. G., 433 Hazel St., Danville, Ill.,
Harris, Chester A., Champaign, Ill.
Haskins, Joseph, County Mine Inspector, Catlin, Ill.
Herbert, C. A., Gen. Supt., Chicago, Wilmington & Vermilion Coal Co., Streator, Ill.
Holinan, Harry A., Mining St., Marseilles, Ill.
Holmes, J. A., U. S. Geological Survey, Washington, D. C.
Howard, F. C., 2017 Fisher Bldg., Chicago, Ill.
Horn, Thos., Duquoin, Ill.
Hutson, E. G. & Sons, Urbana, Ill.
Irving, Robert M., Asst. Mine Inspector, Cayuga, Ind.
John, Evan D., Mgr., Carterville & Big Muddy Coal Co., Carbondale, Ill.
Jones, Thos., Westville, Ill.
Knote, J. M., University of Illinois, Urbana, Ill.
Kressmann, Fred W., Chemistry Bldg., Urbana, Ill.
Kuss, R. H., Asst. Smoke Inspector, 130 Reaper Block, Chicago, Ill.
Lankford, S. N., Georgetown, Ill.
Leaf, C. E., Chemist, C., B. & Q. R. R., Anna, Ill.
Lemmon, T. A., 625 Old Colony Bldg., Chicago, Ill.
Levy, Mike, Supt. C. & B. M. C. Co., Reeves, Ill.
Lindgren, J. M., Chemistry Bldg., University of Illinois, Urbana, Ill.
Little, Thomas, State Inspector of Mines, Murphysboro, Ill.
Lettsome, A. R., E. M., 1300 Old Colony Bldg., Chicago, Ill.
Lord, N. W., Director School of Mines, Ohio State University, Columbus, O.
Lott, Geo. M., Morgan-Gardner Electric Co., 27th St. and Shields Ave., Chicago, Ill.
McAllister, Hector, State Inspector of Mines, 1006 N. Bloomington St., Streator, Ill.
McKee, W. M., Mgr. St. Louis Branch, The Jeffery Mfg. Co., Pierce Bldg., St. Louis, Mo.
McLaren, A. B., Marion, Ill.
Mauck, L. T., Owner and Operator Tilton Coal Co., Danville, Ill.
Mauck, Wm., Danville, Ill.
May, E. A., 282 Michigan Ave., Chicago, Ill., American Radiator Co.
Mears, Brainerd, 1105 W. Oregon St., Urbana, Ill.
Medill, Robt. M., Westville, Ill.
Miller, A. W., Glen Carbon, Ill.
Miller, J. S., Superior Coal Co., Gillespie, Ill.
Miller, J. W., Gen. Supt. Superior Coal Co., Gillespie, Ill.
Monnett, O., Power and The Engine, 355 Dearborn St., Chicago, Ill.
Morris, J. J., Asst. Supt. O'Gara Coal Co., Harrisburg, Ill.
Moses, Tom, State Mine Inspector, Westville, Ill.
Newsam, Richard, President State Mining Board, Woolner Bldg., Peoria, Ill.
Overholt, Lewis, Gen. Mgr., Decatur Coal Co., Decatur, Ill.
Parker, Edward W., U. S. Geological Survey, Washington, D. C.
Parr, S. W., Professor of Applied Chemistry, University of Illinois, Urbana, Ill.
Peters, J. D., Carbondale, Ill.
Peterson, John H. D., Link Belt Co., Chicago, Ill.
Pierce, Chas. I., President Big Creek Colliery Co., Chicago, Ill., 1737 First Nat'l Bank Bldg.
Pleschner, O. J., Mining Engineer, Westville, Ill.
P. H. Proctor, Mine Manager, Marseilles Coal Co., Marseilles, Ill.
Quartier, John B., Westville, Ill.
Quigley, Joseph, Norris Coal Mining Co., Norris, Ill., Fulton Co.
Ramsey, Gilbert, Westville, Ill.
Randall, D. T., U. S. Geological Survey, 40th and Butler Sts., Pittsburgh, Pa.
Rice, G. S., Min. Engr., U. S. Geological Survey, 40th and Butler Sts, Pittsburgh, Pa.
Rollo, George, Pana, Ill.
Rowden, J. C., Urbana, Ill.

Ruhoff, O. E., Mineral Point Zinc Co., Depue, Ill.
Russell, John R., Danville, Ill.
Scholz, Carl, Mgr. Mining Dept., C., R. I. & P. R. R., Old Colony Bldg., Chicago, Ill.
Scott, W. D., Urbana, Ill.
Seley, C. A., Mech. Engr., C., R. I. & P. Ry., Chicago, Ill.
Shafer, Silas A., Assumption, Ill.
Simmons, Charles, 767 South First Ave., Canton, Ill.
Simmons, J. L., Canton, Ill.
Simpson, Geo. A., Mt. Olive, Ill.
Sisley, Geo. E., The Mining World, 1422 Monadnock Bldg., Chicago, Ill.
Smith, Geo. Otis, Director, U. S. Geological Survey, Washington, D. C.
Smith, S. Kedzie, Gen. Supt. Dering Coal Co., Chicago, Ill.
Snodgrass, J. M., In charge of Fuel Investigations, Engineering Experiment Station, Urbana, Ill.
Somermeui, E. E., Ohio State University, Columbus, O.
Spicer, Chas. B., c/o E. I. du Pont de Nemours Powder Co., 1401 Wright Bldg., St. Louis, Mo.
Staubitz, F. H., Golconda, Ill.
Stevens, Chas. E., Grape Creek, Ill.
Stoek, H. H., Editor Mines and Minerals, Scranton, Pa.
Stull, R. T., University of Illinois, Urbana, Ill.
Taylor, E. H., Commercial Testing and Engineering Co., Old Colony Bldg., Chicago, Ill.
Taylor, H. H., Fisher Bldg., Chicago, Ill.
Taylor, James, State Inspector of Mines, Peoria, Ill.
Templeton, John A., Linton, Ind.
Thomas, Harry, O'Gara Coal Co., Harrisburg, Ill.
Thomas, J. Ed., Westville, Ill.
Thomas, Jonathan, Asst. Inspector of Mines, Brazil, Ind.
Tinlin, Charles, Austin Powder Co., 19 Wabash Ave., Chicago, Ill.
Traer, Glen W., Illinois Coal Operators Assn., 1110 Fisher Bldg., Chicago, Ill.
Udden, J. A., Professor of Geology, Augustana College, Rock Island, Ill.
Urbain, Frank J., United Coal Mining Co., Christopher, Ill.
Verner, John, Chariton, Iowa.
Wainwright, Sweetwater, Ill.
Watts, W. I., Supt. Z. D. C. Co., Christopher, Ill.
Weeks, Thos., State Inspector of Mines, Bloomington, Ill.
Weller, Stuart, Professor of Geology, University of Chicago, Chicago, Ill.
Wheeler, W. F., Chemistry Bldg., University of Illinois, Urbana, Ill.
Wilkinson, Frank, Catlin, Ill.
Williams, R. Y., Min. Engr., U. S. Geological Survey, Urbana, Ill.
Williams, W. S., Chemistry Bldg., Urbana, Ill.
Willson, Hiram, Mgr. Big Muddy Coal and Iron Co., Murphysboro, Ill.
Wilson, Wm. A., Sparta, Ill., Box 379.
Wright, F. P.. Crescent Coal Co., Bevier, Ky.
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LIST OF PUBLICATIONS.

Bulletins.

Bulletin 1. The Geological Map of Illinois, by Stuart Weller. Including a folded, colored geological map of the State on the scale of 12 miles to the inch, with descriptive text of 26 pages. (Out of print.)

Bulletin 2. The Petroleum Industry of Southeastern Illinois, by W. S. Blatchley. Preliminary report descriptive of condition up to May 10th, 1906. 109 pages. (Out of print.)

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